Finanziato dall'Unione europea
NextGenerationEU

Ministero dell'Università e della Ricerca
Direzione generale dell'internazionalizzazione e della comunicazione

Avviso per la *"Concessione di finanziamenti destinati alla realizzazione o ammodernamento di Infrastrutture Tecnologiche di Innovazione"* da finanziare nell'ambito del PNRR

Piano Nazionale di Ripresa e Resilienza, Missione 4, *"Istruzione e Ricerca"* - Componente 2, *"Dalla ricerca all'impresa"* - Linea di investimento 3.1, *"Fondo per la realizzazione di un sistema integrato di infrastrutture di ricerca e innovazione"*, finanziato dall'Unione europea - NextGenerationEU

Proposta definitiva

Intervention field 6: Investment in digital capacities and deployment of advanced technologies
DESI dimension 4: Integration of digital technologies + ad hoc data collections
055 - Other types of ICT infrastructure(including large - scale computer resources / equipment, data centres, sensors and other wireless equipment)

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MUR
Ministero dell'Università e della Ricerca

Spett.le
Ministero dell'università e della ricerca
Direzione Generale dell'internazionalizzazione e della comunicazione
Via Michele Carcani, 61 – 00153 ROMA

OGGETTO: Proposta definitiva in esito alla fase negoziale per l'accesso alle agevolazioni previste dall'Avviso per la concessione di finanziamenti destinati alla realizzazione o ammodernamento di Infrastrutture Tecnologiche di Innovazione, da finanziare nell'ambito del PNRR – Progetto identificato con il codice 2165064C – HPMI

Il sottoscritto Maria Chiara Carrozza, nato a PISA il 16/09/1965, nella sua qualità di legale rappresentante (ovvero, procuratore speciale, in forza di idonea e adeguata procura speciale) del Soggetto Proponente Consiglio Nazionale delle Ricerche – CNR, con sede legale in ROMA, alla via P.le Aldo Moro, 7,

DICHIARA

- che la proposta definitiva è coerente con gli esiti della fase negoziale espletata a norma dell'art. 11 dell'Avviso in parola;

DICHIARA, altresì

- di confermare tutto quanto già dichiarato in sede di presentazione della Domanda recante Codice 2165064C
- di essere consapevole che, in caso di dichiarazioni mendaci, ovunque rilasciate nel contesto della presente proposta e nei documenti ad essa allegati, potrà incorrere nelle sanzioni penali richiamate dall'art. 76 del D.P.R. 445/2000, oltre alla decadenza dai benefici, come previsto dall'art. 75 del D.P.R. in parola, conseguenti il provvedimento emanato in base alle dichiarazioni non veritiere;
- di consentire al trattamento dei dati personali per le finalità e con le modalità di cui al decreto legislativo 30 giugno 2003, n. 196, e successive modifiche ed integrazioni.

PRESENTA

la proposta progettuale identificata nella piattaforma GEA con il codice ITEC0000005, di cui alla presente. Costituiscono parte integrante e sostanziale della proposta tutti gli allegati indicati nella Sezione Allegati, che si intendono sottoscritti in uno alla presente, nonché gli Allegati trasmessi in sede di presentazione della domanda, come modificati in questa sede.

Firmato digitalmente

ROSARIO
CORRADO
SPINELLA
20.06.2022
10:05:09 UTC

Proposta definitiva

Avviso per la “Concessione di finanziamenti destinati alla realizzazione o ammodernamento di Infrastrutture Tecnologiche di Innovazione” da finanziare nell’ambito del PNRR – Proposta progettuale definitiva in esito alla fase negoziale – Codice 2165064C

Soggetto proponente

- **Anagrafica Soggetto Proponente**
  - Denominazione: Consiglio Nazionale delle Ricerche – CNR
  - Codice CAR: 000193_EIRI
  - CF: 80054330586
  - Pec: protocollo-ammcen@pec.cnr.it
  - Tipologia soggetto: Enti e Istituzioni di Ricerca del conto economico consolidato dello Stato
  - Sede legale:
    - CAP: 00185
    - Via/Piazza: P.le Aldo Moro
    - Civico: 7
    - Comune: ROMA
    - Provincia: ROMA
    - Regione: Lazio
- **Anagrafica Rappresentante Legale**
  - Nome: Maria Chiara
  - Cognome: Carrozza
  - Codice fiscale: CRRMCH65P56G702V
  - E-mail: presidenza@cnr.it
  - Data di nascita: 16/09/1965
  - Comune di nascita: PISA
  - Sesso: Femmina
- **Anagrafica Referente del progetto**
  - Nome: ROSARIO CORRADO
  - Cognome: SPINELLA
  - Telefono: 0649932248
  - Cellulare: 3358263838
  - E-mail: corrado.spinella@imm.cnr.it

Finanziato dall'Unione europea NextGenerationEU

Dati di sintesi della proposta progettuale

Titolo del Progetto: High Performance Microelectronics Infrastructure

Acronimo del Progetto: HPMI

Settori e ambiti prevalenti dell'iniziativa:

- Digitale, industria, aerospazio:

- Transizione digitale
- Tecnologie quantistiche
- Materiali avanzati
- Fotonica

- Clima, energia, mobilità sostenibile:

- Mobilità sostenibile
- Transizione energetica totale

Keywords:

Wide band gap semico; power- and high-freq; 2D-materials; heterogeneous inte; energy efficiency;

Livelli di maturità tecnologica prevalente (TLR): 7;

Data di avvio del progetto: 31/12/2022

Durata del progetto (in mesi): 36

Costo complessivo del progetto: 39.300.000,00 €

Tipologia intervento: Realizzazione/Creazione

Localizzazione

Infrastruttura distribuita: No

Numero sedi: 1

Sede 1

- CAP: 95121
- Via/Piazza: Zona Industriale - Blocco Pantano d'Arci
- Civico: s.n.
- Comune: CATANIA
- Provincia: CATANIA
- Regione: Sicilia

Piano economico

Costi complessivi di progetto

Spese ammissibili	Costi (€) (1)	IVA (€) (2)	Totale (€) (1+2)
a) Spese Manager Infrastruttura ed altre figure manageriali	1.000.000,00	0,00	1.000.000,00
b) Strumentazione scientifica, apparecchiature e macchinari	26.040.983,61	5.729.016,39	31.770.000,00
c) Impianti tecnici generici	2.604.098,36	572.901,64	3.177.000,00
d) Licenze software e brevetti	688.524,59	151.475,41	840.000,00
e) Fabbricati e terreni	0,00	0,00	0,00
f) Recupero, ristrutturazione, riqualificazione e ampliamento immobili	0,00	0,00	0,00
g) Spese per progettazione e altre spese tecniche	491.803,28	108.196,72	600.000,00
h) Costi indiretti	1.913.000,00	0,00	1.913.000,00
Totale (€)	32.738.409,84	6.561.590,16	39.300.000,00

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Cronoprogramma di attuazione

Obiettivi intermedi: una sintesi

Codice identificativo	Mese di avvio (dalla data di avvio progetto)	Durata (in mesi)	Stima dei costi (€)
1	31/12/2022	6	1.050.000,00
2	31/12/2022	36	4.009.500,00
3	30/06/2023	15	1.050.000,00
4	30/11/2023	21	2.310.000,00
5	30/06/2023	14	315.000,00
6	30/06/2023	14	525.000,00
7	30/06/2023	14	210.000,00
8	30/11/2023	21	1.890.000,00
9	30/11/2023	21	1.890.000,00
10	31/07/2023	21	1.260.000,00
11	30/09/2023	24	1.260.000,00
12	31/01/2024	20	1.050.000,00
13	31/01/2024	23	1.470.000,00
14	31/01/2024	19	1.470.000,00
15	31/01/2024	20	1.575.000,00
16	31/01/2024	23	3.150.000,00
17	30/09/2023	21	1.365.000,00
18	30/09/2023	11	1.050.000,00
19	30/09/2023	25	1.050.000,00
20	30/09/2023	25	1.050.000,00
21	31/07/2023	20	1.575.000,00
22	30/11/2023	25	4.483.500,00
23	29/02/2024	15	525.000,00
24	31/08/2023	12	367.500,00
25	31/08/2023	16	262.500,00
26	31/01/2024	17	367.500,00
27	30/06/2024	18	472.500,00
28	30/06/2024	16	315.000,00
29	30/06/2024	16	1.050.000,00
30	30/11/2023	25	882.000,00

Totale (€)	39.300.000,00

Obiettivo intermedo: 1

- Descrizione

Appointment of the Infrastructure Manager
At the project start, the Infrastructure Manager (IM) will be appointed with a public selection. The candidates must have a well-recognized international scientific experience in the field of advanced semiconductor materials and devices, and have experience in project management. This action will be completed within 30.06.2023. In the same period, 2 administrative units and 2 technologists will be appointed to support the IM during the building of the infrastructure and for the acquisition of the equipment.

- Mese di Avvio

1

- Durata in Mesi

6

- Deliverables

Appointment of the Infrastructure Manager, administrative and technical personnel

Obiettivo intermedo: 2

- Descrizione

Clean Room Realization
The clean room will be made available in the microelectronics hub of Catania by one of the industrial stakeholders, which will grant its use for HPMI. Hence, the cost of the clean room realization is not explicitly reported in the budget plan, but only the hook-up costs of the equipment and other design and technical expenses are considered. The clean-room will cover an area of approximately 1000m2 with cleanliness class from ISO 4 (in the Yellow Room) to ISO 6 in the Grey Area (for the facilities). The clean-room will be equipped with HEPA fan filter unites and with all the facilities needed by the tools (e.g., distributed process gases, compressed dry air, cooling water, exhaust connections to the scrubber, electric power supply, etc.). The clean-room will have controlled temperature and humidity conditions and will be equipped with perforated tiles floor, automatic doors, viewing windows, glass walls, sprinkler heads/fire suppression, Wi-Fi/network access etc

- Mese di Avvio

1

- Durata in Mesi

36

- Deliverables

Clean room acceptance

Obiettivo intermedo: 3

- Descrizione

Direct Laser Lithography
The objective from Obj. 3 to Obj. 29 consist in the acquisition and installation of the tools inside the clean room. Hence, this action will start after the appointment of the IM. One objective for each tool is considered, whose duration will comprise an update of the market survey to define the cost and specification of the tool, and the implementation of the administrative procedures for its acquisition (e.g. public tender). The objectives are organized in a logical time-sequence and with duration that depend on the complexity of the equipment. Each objective is completed with the installation and testing of the technical specifications of the tool. General details on the characteristics of the tools and criteria for their choice are reported in section B1 of the proposal.

- Mese di Avvio

7

- Durata in Mesi

15

- Deliverables

Direct Laser Lithography acceptance

Obiettivo intermedo: 4

- Descrizione

Electron Beam Lithography
The objective from Obj. 3 to Obj. 29 consist in the acquisition and installation of the tools inside the clean room. Hence, this action will start after the appointment of the IM. One objective for each tool is considered, whose duration will comprise an update of the market survey to define the cost and specification of the tool, and the implementation of the administrative procedures for its acquisition (e.g. public tender). The objectives are organized in a logical time-sequence and with duration that depend on the complexity of the equipment. Each objective is completed with the installation and testing of the technical specifications of the tool. General details on the characteristics of the tools and criteria for their choice are reported in section B1 of the proposal.

- Mese di Avvio

12

- Durata in Mesi

21

- Deliverables

Electron Beam Lithography acceptance

Obiettivo intermedo: 5

- Descrizione

Spin coating/developing/pre- and post-bake
The objective from Obj. 3 to Obj. 29 consist in the acquisition and installation of the tools inside the clean room. Hence, this action will start after the appointment of the IM. One objective for each tool is considered, whose duration will comprise an update of the market survey to define the cost and specification of the tool, and the implementation of the administrative procedures for its acquisition (e.g. public tender). The objectives are organized in a logical time-sequence and with duration that depend on the complexity of the equipment. Each objective is completed with the installation and testing of the technical specifications of the tool. General details on the characteristics of the tools and criteria for their choice are reported in section B1 of the proposal.

- Mese di Avvio

7

- Durata in Mesi

14

- Deliverables

Spin coating/developing/pre- and post-bake acceptance

Obiettivo intermedo: 6

- Descrizione

Wet chemical benches
The objective from Obj. 3 to Obj. 29 consist in the acquisition and installation of the tools inside the clean room. Hence, this action will start after the appointment of the IM. One objective for each tool is considered, whose duration will comprise an update of the market survey to define the cost and specification of the tool, and the implementation of the administrative procedures for its acquisition (e.g. public tender). The objectives are organized in a logical time-sequence and with duration that depend on the complexity of the equipment. Each objective is completed with the installation and testing of the technical specifications of the tool. General details on the characteristics of the tools and criteria for their choice are reported in section B1 of the proposal.

- Mese di Avvio

7

- Durata in Mesi

14

- Deliverables

Wet chemical benches acceptance

Obiettivo intermedo: 7

- Descrizione

Spin dryers
The objective from Obj. 3 to Obj. 29 consist in the acquisition and installation of the tools inside the clean room. Hence, this action will start after the appointment of the IM. One objective for each tool is considered, whose duration will comprise an update of the market survey to define the cost and specification of the tool, and the implementation of the administrative procedures for its acquisition (e.g. public tender). The objectives are organized in a logical time-sequence and with duration that depend on the complexity of the equipment. Each objective is completed with the installation and testing of the technical specifications of the tool. General details on the characteristics of the tools and criteria for their choice are reported in section B1 of the proposal.

- Mese di Avvio

  7

- Durata in Mesi

  14

- Deliverables

  Spin dryers acceptance

Obiettivo intermedo: 8

- Descrizione

  Plasma-Enhanced CVD system
The objective from Obj. 3 to Obj. 29 consist in the acquisition and installation of the tools inside the clean room. Hence, this action will start after the appointment of the IM. One objective for each tool is considered, whose duration will comprise an update of the market survey to define the cost and specification of the tool, and the implementation of the administrative procedures for its acquisition (e.g. public tender). The objectives are organized in a logical time-sequence and with duration that depend on the complexity of the equipment. Each objective is completed with the installation and testing of the technical specifications of the tool. General details on the characteristics of the tools and criteria for their choice are reported in section B1 of the proposal.

- Mese di Avvio

  12

- Durata in Mesi

  21

- Deliverables

  Plasma-Enhanced CVD system acceptance

Obiettivo intermedo: 9

- Descrizione

  Low Pressure CVD system
The objective from Obj. 3 to Obj. 29 consist in the acquisition and installation of the tools inside the clean room. Hence, this action will start after the appointment of the IM. One objective for each tool is considered, whose duration will comprise an update of the market survey to define the cost and specification of the tool, and the implementation of the administrative procedures for its acquisition (e.g. public tender). The objectives are organized in a logical time-sequence and with duration that depend on the complexity of the equipment. Each objective is completed with the installation and testing of the technical specifications of the tool. General details on the characteristics of the tools and criteria for their choice are reported in section B1 of the proposal.

- Mese di Avvio

  12

- Durata in Mesi

21

• Deliverables

Low Pressure CVD system acceptance

Obiettivo intermedo: 10

• Descrizione

Electron Beam Evaporator
The objective from Obj. 3 to Obj. 29 consist in the acquisition and installation of the tools inside the clean room. Hence, this action will start after the appointment of the IM. One objective for each tool is considered, whose duration will comprise an update of the market survey to define the cost and specification of the tool, and the implementation of the administrative procedures for its acquisition (e.g. public tender). The objectives are organized in a logical time-sequence and with duration that depend on the complexity of the equipment. Each objective is completed with the installation and testing of the technical specifications of the tool. General details on the characteristics of the tools and criteria for their choice are reported in section B1 of the proposal.

• Mese di Avvio

8

• Durata in Mesi

21

• Deliverables

Electron Beam Evaporator acceptance

Obiettivo intermedo: 11

• Descrizione

DC/RF Sputter Deposition System
The objective from Obj. 3 to Obj. 29 consist in the acquisition and installation of the tools inside the clean room. Hence, this action will start after the appointment of the IM. One objective for each tool is considered, whose duration will comprise an update of the market survey to define the cost and specification of the tool, and the implementation of the administrative procedures for its acquisition (e.g. public tender). The objectives are organized in a logical time-sequence and with duration that depend on the complexity of the equipment. Each objective is completed with the installation and testing of the technical specifications of the tool. General details on the characteristics of the tools and criteria for their choice are reported in section B1 of the proposal.

• Mese di Avvio

10

• Durata in Mesi

24

• Deliverables

DC/RF Sputter Deposition System acceptance

Obiettivo intermedo: 12

- Descrizione

Atomic Layer Deposition
The objective from Obj. 3 to Obj. 29 consist in the acquisition and installation of the tools inside the clean room. Hence, this action will start after the appointment of the IM. One objective for each tool is considered, whose duration will comprise an update of the market survey to define the cost and specification of the tool, and the implementation of the administrative procedures for its acquisition (e.g. public tender). The objectives are organized in a logical time-sequence and with duration that depend on the complexity of the equipment. Each objective is completed with the installation and testing of the technical specifications of the tool. General details on the characteristics of the tools and criteria for their choice are reported in section B1 of the proposal.

- Mese di Avvio

14

- Durata in Mesi

20

- Deliverables

Atomic Layer Deposition acceptance

Obiettivo intermedo: 13

- Descrizione

MOCVD reactor for oxides
The objective from Obj. 3 to Obj. 29 consist in the acquisition and installation of the tools inside the clean room. Hence, this action will start after the appointment of the IM. One objective for each tool is considered, whose duration will comprise an update of the market survey to define the cost and specification of the tool, and the implementation of the administrative procedures for its acquisition (e.g. public tender). The objectives are organized in a logical time-sequence and with duration that depend on the complexity of the equipment. Each objective is completed with the installation and testing of the technical specifications of the tool. General details on the characteristics of the tools and criteria for their choice are reported in section B1 of the proposal.

- Mese di Avvio

14

- Durata in Mesi

23

- Deliverables

MOCVD reactor for oxides acceptance

Obiettivo intermedo: 14

- Descrizione

CVD reactor for 2D materials
The objective from Obj. 3 to Obj. 29 consist in the acquisition and installation of the tools inside the clean room. Hence, this action will start after the appointment of the IM. One objective for each tool is considered, whose duration will comprise an update of the market survey to define the cost and specification of the tool, and the implementation of the administrative procedures for its acquisition (e.g. public tender). The objectives are organized in a logical time-sequence and with duration that depend on the complexity of the equipment. Each objective is completed with the installation and testing of the technical specifications of the tool. General details on the characteristics of the tools and criteria for their choice are reported in section B1 of the proposal.

- Mese di Avvio

14

- Durata in Mesi

19

- Deliverables

CVD reactor for 2D materials acceptance

Obiettivo intermedo: 15

- Descrizione

LP-CVD reactor for poly SiC
The objective from Obj. 3 to Obj. 29 consist in the acquisition and installation of the tools inside the clean room. Hence, this action will start after the appointment of the IM. One objective for each tool is considered, whose duration will comprise an update of the market survey to define the cost and specification of the tool, and the implementation of the administrative procedures for its acquisition (e.g. public tender). The objectives are organized in a logical time-sequence and with duration that depend on the complexity of the equipment. Each objective is completed with the installation and testing of the technical specifications of the tool. General details on the characteristics of the tools and criteria for their choice are reported in section B1 of the proposal.

- Mese di Avvio

14

- Durata in Mesi

20

- Deliverables

LP-CVD reactor for poly SiC acceptance

Obiettivo intermedo: 16

- Descrizione

CVD reactor for 200mm SiC epitaxy
The objective from Obj. 3 to Obj. 29 consist in the acquisition and installation of the tools inside the clean room. Hence, this action will start after the appointment of the IM. One objective for each tool is considered, whose duration will comprise an update of the market survey to define the cost and specification of the tool, and the implementation of the administrative procedures for its acquisition (e.g. public tender). The objectives are organized in a logical time-sequence and with duration that depend on the complexity of the equipment. Each objective is completed with the installation and testing of the technical specifications of the tool. General details on the characteristics of the tools and criteria for their choice are reported in section B1 of the proposal.

- Mese di Avvio

14

- Durata in Mesi

23

- Deliverables

CVD reactor for 200mm SiC epitaxy acceptance

Obiettivo intermedo: 17

- Descrizione

Inductively Coupled Plasma (ICP) dry etcher
The objective from Obj. 3 to Obj. 29 consist in the acquisition and installation of the tools inside the clean room. Hence, this action will start after the appointment of the IM. One objective for each tool is considered, whose duration will comprise an update of the market survey to define the cost and specification of the tool, and the implementation of the administrative procedures for its acquisition (e.g. public tender). The objectives are organized in a logical time-sequence and with duration that depend on the complexity of the equipment. Each objective is completed with the installation and testing of the technical specifications of the tool. General details on the characteristics of the tools and criteria for their choice are reported in section B1 of the proposal.

- Mese di Avvio

10

- Durata in Mesi

21

- Deliverables

Inductively Coupled Plasma (ICP) dry etcher acceptance

Obiettivo intermedo: 18

- Descrizione

Rapid Thermal Annealing (RTA) system
The objective from Obj. 3 to Obj. 29 consist in the acquisition and installation of the tools inside the clean room. Hence, this action will start after the appointment of the IM. One objective for each tool is considered, whose duration will comprise an update of the market survey to define the cost and specification of the tool, and the implementation of the administrative procedures for its acquisition (e.g. public tender). The objectives are organized in a logical time-sequence and with duration that depend on the complexity of the equipment. Each objective is completed with the installation and testing of the technical specifications of the tool. General details on the characteristics of the tools and criteria for their choice are reported in section B1 of the proposal.

- Mese di Avvio

10

- Durata in Mesi

11

• Deliverables

Rapid Thermal Annealing (RTA) system acceptance

Obiettivo intermedo: 19

• Descrizione

High-temperature furnace for SiC dopant activation
The objective from Obj. 3 to Obj. 29 consist in the acquisition and installation of the tools inside the clean room. Hence, this action will start after the appointment of the IM. One objective for each tool is considered, whose duration will comprise an update of the market survey to define the cost and specification of the tool, and the implementation of the administrative procedures for its acquisition (e.g. public tender). The objectives are organized in a logical time-sequence and with duration that depend on the complexity of the equipment. Each objective is completed with the installation and testing of the technical specifications of the tool. General details on the characteristics of the tools and criteria for their choice are reported in section B1 of the proposal.

• Mese di Avvio

10

• Durata in Mesi

25

• Deliverables

High-temperature furnace for SiC dopant activation acceptance

Obiettivo intermedo: 20

• Descrizione

High-temperature oxidation furnace for SiC
The objective from Obj. 3 to Obj. 29 consist in the acquisition and installation of the tools inside the clean room. Hence, this action will start after the appointment of the IM. One objective for each tool is considered, whose duration will comprise an update of the market survey to define the cost and specification of the tool, and the implementation of the administrative procedures for its acquisition (e.g. public tender). The objectives are organized in a logical time-sequence and with duration that depend on the complexity of the equipment. Each objective is completed with the installation and testing of the technical specifications of the tool. General details on the characteristics of the tools and criteria for their choice are reported in section B1 of the proposal.

• Mese di Avvio

10

• Durata in Mesi

25

• Deliverables

High-temperature oxidation furnace for SiC acceptance

Obiettivo intermedo: 21

- Descrizione

Horizontal furnaces (multiple tubes)
The objective from Obj. 3 to Obj. 29 consist in the acquisition and installation of the tools inside the clean room. Hence, this action will start after the appointment of the IM. One objective for each tool is considered, whose duration will comprise an update of the market survey to define the cost and specification of the tool, and the implementation of the administrative procedures for its acquisition (e.g. public tender). The objectives are organized in a logical time-sequence and with duration that depend on the complexity of the equipment. Each objective is completed with the installation and testing of the technical specifications of the tool. General details on the characteristics of the tools and criteria for their choice are reported in section B1 of the proposal.

- Mese di Avvio

8

- Durata in Mesi

20

- Deliverables

Horizontal furnaces (multiple tubes) acceptance

Obiettivo intermedo: 22

- Descrizione

Ion-implanter with hot implantation capability
The objective from Obj. 3 to Obj. 29 consist in the acquisition and installation of the tools inside the clean room. Hence, this action will start after the appointment of the IM. One objective for each tool is considered, whose duration will comprise an update of the market survey to define the cost and specification of the tool, and the implementation of the administrative procedures for its acquisition (e.g. public tender). The objectives are organized in a logical time-sequence and with duration that depend on the complexity of the equipment. Each objective is completed with the installation and testing of the technical specifications of the tool. General details on the characteristics of the tools and criteria for their choice are reported in section B1 of the proposal.

- Mese di Avvio

12

- Durata in Mesi

25

- Deliverables

Ion-implanter with hot implantation capability acceptance

Obiettivo intermedo: 23

- Descrizione

Chemical Mechanical Polishing
The objective from Obj. 3 to Obj. 29 consist in the acquisition and installation of the tools inside the clean room. Hence, this action will start after the appointment of the IM. One objective for each tool is considered, whose duration will comprise an update of the market survey to define the cost and specification of the tool, and the implementation of the administrative procedures for its acquisition (e.g. public tender). The objectives are organized in a logical time-sequence and with duration that depend on the complexity of the equipment. Each objective is completed with the installation and testing of the technical specifications of the tool. General details on the characteristics of the tools and criteria for their choice are reported in section B1 of the proposal.

- Mese di Avvio

15

- Durata in Mesi

15

- Deliverables

Chemical Mechanical Polishing acceptance

Obiettivo intermedo: 24

- Descrizione

Optical microscope
The objective from Obj. 3 to Obj. 29 consist in the acquisition and installation of the tools inside the clean room. Hence, this action will start after the appointment of the IM. One objective for each tool is considered, whose duration will comprise an update of the market survey to define the cost and specification of the tool, and the implementation of the administrative procedures for its acquisition (e.g. public tender). The objectives are organized in a logical time-sequence and with duration that depend on the complexity of the equipment. Each objective is completed with the installation and testing of the technical specifications of the tool. General details on the characteristics of the tools and criteria for their choice are reported in section B1 of the proposal.

- Mese di Avvio

9

- Durata in Mesi

12

- Deliverables

Optical microscope acceptance

Obiettivo intermedo: 25

- Descrizione

Profilometer
The objective from Obj. 3 to Obj. 29 consist in the acquisition and installation of the tools inside the clean room. Hence, this action will start after the appointment of the IM. One objective for each tool is considered, whose duration will comprise an update of the market survey to define the cost and specification of the tool, and the implementation of the administrative procedures for its acquisition (e.g. public tender). The objectives are organized in a logical time-sequence and with duration that depend on the complexity of the equipment. Each objective is completed with the installation and testing of the technical specifications of the tool. General details on the characteristics of the tools and criteria for their choice are reported in section B1 of the proposal.

- Mese di Avvio

  9

- Durata in Mesi

  16

- Deliverables

  Profilometer acceptance

Obiettivo intermedo: 26

- Descrizione

  Spectroscopic Ellipsometer

The objective from Obj. 3 to Obj. 29 consist in the acquisition and installation of the tools inside the clean room. Hence, this action will start after the appointment of the IM. One objective for each tool is considered, whose duration will comprise an update of the market survey to define the cost and specification of the tool, and the implementation of the administrative procedures for its acquisition (e.g. public tender). The objectives are organized in a logical time-sequence and with duration that depend on the complexity of the equipment. Each objective is completed with the installation and testing of the technical specifications of the tool. General details on the characteristics of the tools and criteria for their choice are reported in section B1 of the proposal.

- Mese di Avvio

  14

- Durata in Mesi

  17

- Deliverables

  Spectroscopic Ellipsometer acceptance

Obiettivo intermedo: 27

- Descrizione

  Non-contact sheet resistance and Hall effect measurements

The objective from Obj. 3 to Obj. 29 consist in the acquisition and installation of the tools inside the clean room. Hence, this action will start after the appointment of the IM. One objective for each tool is considered, whose duration will comprise an update of the market survey to define the cost and specification of the tool, and the implementation of the administrative procedures for its acquisition (e.g. public tender). The objectives are organized in a logical time-sequence and with duration that depend on the complexity of the equipment. Each objective is completed with the installation and testing of the technical specifications of the tool. General details on the characteristics of the tools and criteria for their choice are reported in section B1 of the proposal.

- Mese di Avvio

  19

- Durata in Mesi

18

• Deliverables

Non-contact sheet resistance and Hall effect measurements acceptance

Obiettivo intermedo: 28

• Descrizione

Hg-probe system
The objective from Obj. 3 to Obj. 29 consist in the acquisition and installation of the tools inside the clean room. Hence, this action will start after the appointment of the IM. One objective for each tool is considered, whose duration will comprise an update of the market survey to define the cost and specification of the tool, and the implementation of the administrative procedures for its acquisition (e.g. public tender). The objectives are organized in a logical time-sequence and with duration that depend on the complexity of the equipment. Each objective is completed with the installation and testing of the technical specifications of the tool. General details on the characteristics of the tools and criteria for their choice are reported in section B1 of the proposal.

• Mese di Avvio

19

• Durata in Mesi

16

• Deliverables

Hg-probe system acceptance

Obiettivo intermedo: 29

• Descrizione

Probe station for in-line wafer-level testing
The objective from Obj. 3 to Obj. 29 consist in the acquisition and installation of the tools inside the clean room. Hence, this action will start after the appointment of the IM. One objective for each tool is considered, whose duration will comprise an update of the market survey to define the cost and specification of the tool, and the implementation of the administrative procedures for its acquisition (e.g. public tender). The objectives are organized in a logical time-sequence and with duration that depend on the complexity of the equipment. Each objective is completed with the installation and testing of the technical specifications of the tool. General details on the characteristics of the tools and criteria for their choice are reported in section B1 of the proposal.

• Mese di Avvio

19

• Durata in Mesi

16

• Deliverables

Probe station for in-line wafer-level testing acceptance

Obiettivo intermedo: 30

- Descrizione

Digitalization and Testing of the pilot-line
The final objective is to equip the pilot-line with its software platform interconnecting the tools and to test the pilot-line by running single processing steps, simple flow-charts, up to the fabrication prototypes. Hence, this action will start at M12 and will be continuously implemented during the acquisition of the single tools. A customized asset tracking software will be developed by a specialized company and tested to manage all the operations of the infrastructure, using appropriate protocols. For process testing, at the beginning, after the acquisition of the first tools, single steps like lithography or metal depositions will be tested, and then integrated in simple flow-charts for test-structures. Finally, when more complex equipment will be acquired (like dielectric depositions, plasma etch, ion implantation, etc.) some prototype will be realized, focusing first on more consolidated SiC or GaN processes.

- Mese di Avvio

12

- Durata in Mesi

25

- Deliverables

Acceptance of software platform

Allegati

Allegato 1 - Proposal template

ROSARIO
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20.06.2022
10:05:52 UTC

Ministero dell'Università e della Ricerca
Direzione generale dell'internazionalizzazione e della comunicazione

Avviso per la *"Concessione di finanziamenti destinati alla realizzazione o ammodernamento di Infrastrutture Tecnologiche di Innovazione"* da finanziare nell'ambito del PNRR
Missione 4, "*Istruzione e Ricerca*" - Componente 2, "*Dalla ricerca all'impresa*"

Linea di investimento 3.1, "*Fondo per la realizzazione di un sistema integrato di infrastrutture di ricerca e innovazione",*
finanziato dall'Unione europea – NextGeneration EU

REFORMS AND INVESTMENTS UNDER THE RECOVERY AND RESILIENCE PLAN
NextGenerationEU

Call for proposals

Intervention field 6: Investment in digital capacities and deployment of advanced technologies DESI dimension 4: Integration of digital technologies + ad hoc data collections
055 - Other types of ICT infrastructure (including large-scale computer resources/equipment, data centres, sensors and other wireless equipment)
Mission 4 – "Education and Research"
Component 2: from research to business
Investment 3.1: "Fund for the realisation of an integrated system of research and innovation infrastructures

Annex1 (technical annex)

Proposal template, pursuant to Article 8 of the call for proposals
(To be provided in English only)

DISCLAIMER: This document is aimed at informing potential applicants for call-PNRR funding. It serves only as an example. The actual Web forms and templates, provided in the online proposal submission system under the online proposal submission system, might differ from this example. Proposals must be prepared and submitted only via the online proposal submission system.

HIGH PERFORMANCE MICROELECTRONICS INFRASTRUCTURE (HPMI)

INFRASTRUTTURA PER LA MICROELETTRONICA AD ALTE PRESTAZIONI (IMAP)

Part A – Strategic framework of the initiative

A.1. Objectives of the initiative

Until the late 90s, semiconductor technologies were driven by miniaturization in digital CMOS applications, as described by Moore's Law. However, the advent of nanotechnologies and new materials (e.g., wide-band-gap semiconductors, topological insulators, 2D materials, etc.), gradually led to move towards a "More than Moore" approach, referring to the incorporation of *non-digital* functionalities into devices (e.g., RF communication, power control, passive components, sensors, actuators).

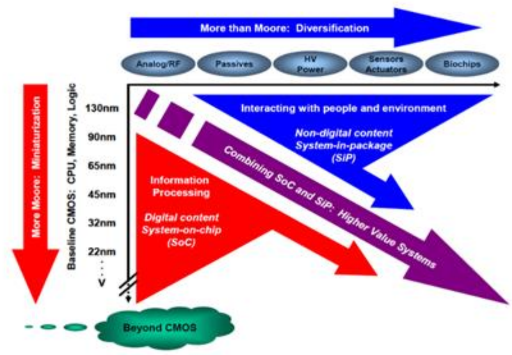

Fig. 1: More than Moore law

In this field, Europe plays a leading role with top suppliers of semiconductor devices (Infineon, STMicroelectronics and NXP). Hence, some European countries put strong efforts on the creation of **large infrastructures** focused on innovation and technology transfer in micro- and nano-electronics (e.g., MINATEC, IMEC, IHP, Fraunhofer IIS, etc.). In addition, also **small–medium infrastructures** (typically spin-off of Universities or Research Centers), have been created to address specific technological challenges (e.g., ICTS, AMO GmbH, NamLab, etc.). The absence of similar research infrastructures in Italy, based on a **technology diversification and medium-high TRL** is a serious drawback in the transfer of knowledge from academia to industry.

Fig. 2: Examples of large research infrastructures in EU

The **"High Performance Microelectronics Infrastructure" (HPMI)** will be a "front-end pilot-line" located in a clean room environment in the *microelectronics hub of Catania*, equipped with state-of-the-art versatile instruments and in-line metrology tools, and managed with a customized software platform. Its main objectives are:

- **develop key enabling technologies (KETs) on advanced materials** for next generation of micro–nanoelectronic devices, for several applications fields, e.g. like *automotive*, *consumer electronics*, *data communication*, *sustainable energy*, *efficient power management*, *aerospace*, *robotics*, etc.
- **favour the convergence of multiple competences** coming from Si world and going beyond Si, and **train a new generation of young researchers** within an innovative environment.
- **identify the most promising source of innovations** and **potential business**, to sustain the Italian industry in ***IP development and technological transfer***, and **increase the competitiveness of the Country** within and outside EU.

Specifically, the scientific objectives targeted from the project will be: (1) the development the KETs for the high-energy-efficiency (up to 99%) unipolar (JBS diodes, MOSFETs, HEMTs and MISHEMTs) and bipolar (p-n diodes, BJT) power devices based on SiC, GaN and Ga_2O_3; (2) the large-scale integration of 2D materials (like graphene, MoS_2 etc.) on WBG semiconductors for novel high-frequency devices (HETs, barristors, etc.) operating up to the THz.

The disruptive technologies required for the competitiveness in microelectronics can be favored by a strong link between public research and private investments. In this context, Catania is a reference, thanks to the virtuous interaction among the University, CNR and Industry.

Hence, HPMI has the ambitious goal of **covering the path from fundamental research to technological applications**, by strengthening the public-private interaction experienced in the microelectronic hub of Catania. In fact, the public-private-partnership will favour the sharing of resources and skills committed to both fundamental research and technological transfer activities, which are a crucial to move towards high TRLs.

The activities carried out at HPMI will be extremely diversified, focusing on *beyond–silicon* technologies based on wide–band–gap and ultra-wide-band-gap semiconductors, 2D materials and their hybrid integration. The pilot–line will provide the ideal environment for academics and industrial stakeholders to further develop or explore these new technologies that still require excellence research and technological expertise. The microelectronics Industry can commit HPMI to implement the entire chain of processes necessary to realize novel processes and devices prompt for the industrial qualification.

A.2. Geographical area of interest

Since the late 90s, Catania showed a vocation in microelectronics, in the so-called "Etna Valley", with 10.6% of employees with respect to all the other local manufacturing activities (4.4% and 3.7% at Regional and National level). Hence, Sicily is experiencing a notable economic recovery associated with the microelectronics, whose export has significantly increased in the last years. The majority of foreign turnover is realized in the EU market (81.5%), but extra-EU export is growing at a faster rate.

Catania plays a crucial role in this scenario thanks to the cooperation among public research (such as University and CNR) and private companies.

For those reasons, HPMI will be located in the *microelectronics hub of Catania*. In these area, STMicroelectronics is increasing its capabilities by building the new fab for SiC materials and device production. The hub includes also the presence of Enel Green Power, active in the field of photovoltaics technologies, and of LPE, a SME whose core business is the development and production of semiconductor epitaxial reactors.

Fig. 3: View of the microelectronic hub of Catania where HPMI will be realized

CNR is present in this area with its research infrastructure "Beyond–Nano" and the Institute for Microelectronics and Microsystems (IMM). In particular, the localization of IMM labs inside STMicroelectronics and LPE fabs allowed a fruitful collaboration, which has attracted significant funds within national (e.g. PON Ambition Power and EleGaNTe) and EU projects (e.g. ECSEL Last Power, WInSiC4AP, REACTION, GaN4AP), making the activities on WBG semiconductors the major feature of the "Etna Valley".

A.3. Sectors/domains

HPMI will operate in the field of *micro- and nano-electronics beyond–silicon*. The **application domains** refer to power- and high-frequency electronics devices, smart systems and optoelectronic/photonic devices, for automotive, industrial components, renewable energy systems, smart sensing, solid–state lighting, etc. The **thematic sectors** addressed by the initiative are:

- *advanced materials*
- *energetic transition*
- *photonics and quantum technologies*

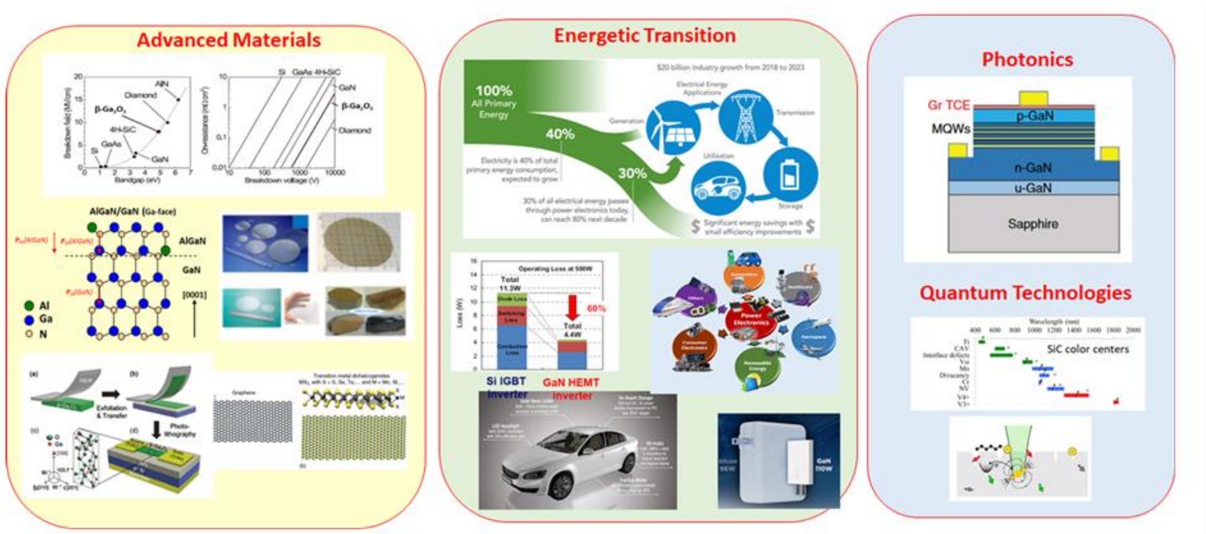

Fig. 4: Thematic sectors addressed by the HPMI initiative.

The focus will be on **advanced materials**, i.e. wide–band–gap (WBG) and ultra-wide-band-gap (UWBG) semiconductors (SiC, GaN, Ga_2O_3, AlN, diamond, etc.), two-dimensional (2D) materials like graphene or MoS_2. Owing to the intrinsic properties of these materials, it is possible to realize devices with superior performance of Si devices, in terms of power consumption. Within 20 years, the greatest part of the electrical energy used worldwide will be managed by power-semiconductors. Hence, advanced power- and high-frequency electronics devices will be more efficient, contributing the reduction of CO_2 emissions and global warming. Hence, the activities of HPMI are fully in line with the EU policies, contributing to the **energetic transition** towards green solutions in the society. Moreover, the integration of 2D materials in the technological platform of WBG semiconductors will add new functionalities to power- and high-frequency devices and open new perspectives in other domains, like **photonics** and **quantum technologies.** For instance, 2D materials as novel electrodes for optical devices, hybrid 2D/WBG heterostructures for THz transmission and sensing, as well the tailoring of WBG semiconductors electro-optical properties, will enable the realization of new optoelectronic and photonics devices and sensors, and quantum emitting devices.

A.4. Keywords

Wide band gap semiconductors, power- and high-frequency electronics, 2D-materials, heterogeneous integration, energy efficiency

A.5. Prevailing levels of TRLs

Depending on the materials and technologies, medium- to high- TRLs are expected. Regarding the mature technologies of SiC and GaN, innovative processing steps (e.g. metallization, dielectrics, etc.) will be developed and demonstrated in industrially relevant environment. A strong interaction with STMicroelectronics is envisaged, aiming at an industrial qualification of the developed processes (TRL 7). For the novel UWBG materials, e.g. the promising Ga_2O_3, KETs development in an industrially relevant environment and simple prototype of diodes or transistors are targeted (TRL 6-7). Finally, a lower level of maturity (TRL 4-6) is expected for the growth of the 2D materials and the demonstration of new devices arising from their heterogeneous integration with WBG semiconductors.

A.6. Coherence with the priorities set in the European, National and Regional strategic agendas

HPMI's objectives are coherent with the latest measures for strengthening Europe's semiconductor ecosystem (**Chips Act**), supporting ***new advanced pilot lines*** to test, validate and further develop the next generation of devices and products. These infrastructures are aimed at bridging the current gap between R&D and manufacturing, providing for the industry a facility to test, experiment and validate new semiconductor technologies and concepts at the higher TRLs (beyond 3 but under 8). In fact, HMPI addresses key Chips Act's *(Art. 4, 2b)* topics, i.e. n*ovel materials and architectures for power electronics fostering sustainable energy and electro mobility, lower energy consumption, […], integrating breakthrough technologies such as graphene and other 2D material based technologies*.
Moreover, the targeted activities are powerful enablers for the ***sustainability transition*** and can lead to new and more energy efficient products, contributing to the objectives of the European *Green Deal* and *2030 Digital Compass*. In fact, the pervasive introduction of these new technologies will guarantee a significant energy saving in many sectors (see also Section B1) and ultimately contribute to the societal de-carbonization and to the limitations of the climate changes. At the same time, the targeted innovative technologies will contribute to the energy efficiency of the key infrastructures for the digital revolution, like data centers.
Regarding the regional policy, **microelectronics** is one of the strategic sectors defined in Smart Specialization Strategy (RIS3) by Sicily Region. However, the Public Investment Evaluation and Verification Unit (NVVIP) ranks Sicily as the second last EU region for employed researchers, suffering from low levels of IP protection, of education level and employment in medium-high technological manufacturing sectors**.** Hence, NVVIP emphasizes the role of **investment in creating and/or strengthening research infrastructures** to improve interaction among University, Research Institutions and Industry and increase the capability of promoting technological innovation. In Section OP1 – *regional policy for research, development, and innovation*, the KETs that are considered crucial for tackling these challenges are: **microelectronics**, artificial intelligence, quantum technologies, 5G.

A.7. Synergies with other initiatives envisaged within Mission 4 ("Education and research"), Component 2 ("From research to enterprise"), with particular, but not exclusive, reference to Investment 3.1 ("Fund for the creation of an integrated system of research and innovation infrastructures")

HPMI will operate in synergy with other initiatives of M4-C2, being complementary and well integrated in the Sicilian Innovation Ecosystem. The *Sicilian Micro and Nano Technology Research and Innovation Center (SAMOTHRACE)* is based on the competences in micro- and nano-technologies, smart devices and innovative materials, and aims at contributing to the innovation chain in energy, health, environment, smart mobility, cultural heritage, agriculture. This initiative includes Universities, Public Research Centers, large companies and SMEs, providing all the competences present in the territory in fundamental research on materials science and devices technology at low TRL (< 4). In this context, HPMI will provide the ultimate bridge between the fundamental research of SAMOTHRACE and the industrial world. Power electronics based on SiC and GaN will be common topics between the two initiatives. HPMI will be also linked to the proposed multi-site research infrastructures *"Nanomaterials and Processes for the Circular Economy and Energetic Transition"* and *"NFFA-Digital Infrastructure"*, providing some processing steps and computational competences in the field of power electronics.

A.8. International profile and reach of potential users (with particular reference to SMEs)

Owing to the well-recognized competences present in the microelectronics hub of Catania, HPMI will have an international vocation. In particular, the consolidated international network of collaborations of CNR-IMM will enable to attract potential academic users in all Europe and become a driving force for new funded projects or business opportunities.

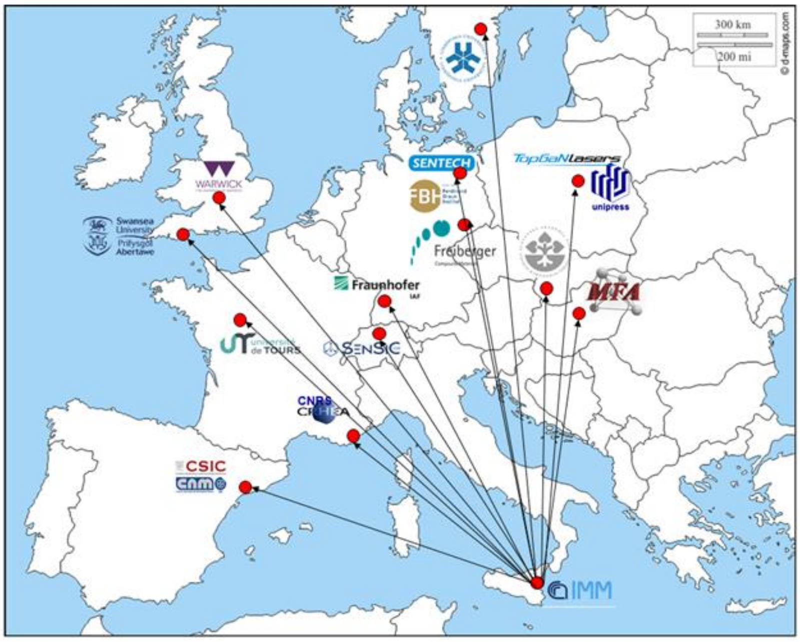

Fig. 5: International collaborative network of CNR-IMM of Catania with academic partners and SMEs.

A network of potential private users and stakeholders has been already identified. In fact, besides the interest of large multinational companies located in Sicily (e.g. STMicroelectronics, Enel Green Power, Leonardo, etc.), HPMI will provide a unique opportunity for several European large companies and SMEs already in the network of CNR (e.g., LPE, SAT, STlab, Aixtron, Centrotherm, Sentech, SenSiC, TopGaN, Annealsys, GaphenSiC Graphenea), which may be interested to implement their own technological products (devices and manufacturing/characterization tools) in several fields, with a specific focus of novel materials, devices processing, detectors/sensors, etc. As currently occurs with most of these partners (see table), the cooperation will be done in the framework of funded initiative and bilateral joint development agreements.

Potential private users/partners of HPMI identified within the collaborative network of CNR				
Company Name	**Country**	**Type of company**	**Business Sector**	**Current or past collaboration with CNR**
STMicroelectronics	Italy	Large	Semiconductor devices	Research contracts, National project PON EleGaNTe, ECSEL-JU projects REACTION and GaN4AP
Enel Green Power	Italy	Large	Photovoltaics	CNR-IMM laboratories located inside Enel Green Power
Meridionale Impianti	Italy	Large	Semiconductor clean room facilities, automation	Continue relations for equipment and clean room maintainance
Leonardo	Italy	Large	Aerospace, defense, security	National project PON EleGaNTe
ENI	Italy	Large	Energy	Mutual collaboration with Industrial PhD fellowships
Aixtron	Germany	Large	Epitaxial Reactors	ECSEL-JU project GaN4AP
Centrotherm	Germany	Large	High temperature annealing	ECSEL-JU project REACTION
II-VI	Sweden	Large	SiC substrates and devices	ECSEL-JU project REACTION
LPE Spa	Italy	SME	Epitaxial Reactors	Research contract, National project PON EleGaNTe, ECSEL-JU project REACTION
SAT Group	Italy	SME	Wet Bench Systems & Fluoropolymer Components	Past collaboration within ECSEL-JU project WInSiC4AP
SC Progetti	Italy	SME	Design & Engineering services	Cooperation within Beyond Nano clean room realization
STlab	Italy	SME	Biomedical devices & harsh environment sensing	Spin-off of CNR-IMM researchers
Freiberger	Germany	SME	Compound Semiconductor Materials	ECSEL-JU project GaN4AP
Sentech GmbH	Germany	SME	Atomic Layer Depositions, Plasma Etchers	New Joint Development Agreement in preparation
SenSiC GmbH	Switzerland	SME	SiC sensors and detectors	Cooperation through STlab spin-off
TopGaN	Poland	SME	Laser diodes and optoelectronic devices	FlagEra Granite, Bilateral Cooperation CNR-PAS (Poland)
Annealsys	France	SME	Annealing equipment	Joint Development Agreement in preparation
Ion Beam Services	France	SME	Ion implanters	Horizon2020 Challenge
GraphenSiC	Sweden	SME	Epitaxial graphene on SiC	Horizon2020 Challenge
Epiluvac	Sweden	SME	Epitaxial Reactors	ENIAC-JU project LAST POWER
Graphenea	Spain	SME	CVD graphene	Past Joint Development Agreement

A.9. Start date of the initiative

31.12.2022

A.10. Please choose one of the following options below:

Single-Site Infrastructure ☒
Multi-Site Infrastructure ☐

Part B – Initiative features

B.1. **Activities**

Nowadays, a significant fraction (~50%) of the global warming is due to the energy production and transportation. In particular, according to the latest intergovernmental Panel on Climate Change (IPCC) report, industry, transportation and electricity generation account for about 60% of the global gas emissions. Hence, most of the energy-related megatrends of our modern society must address themes such *energy efficiency*, *e-mobility*, *smart grid* and *digitalization*, all requiring **green energy management electronics and/or new power- and high-frequency electronic solutions and sensors based on innovative materials.**

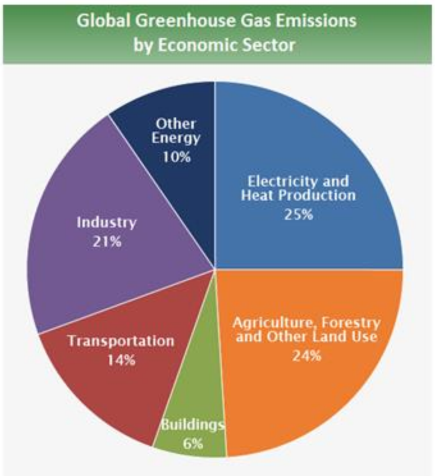

Fig. 6: Global Greenhouse Gas Emission by Economic Sectors - Source: IPCC (2014) https://www.epa.gov/ghgemissions/global-greenhouse-gas-emissions-data (2021).

Considering the overall energy consumption, today around 40% of the power used in the world is electrical and this fraction is expected to increase up to 60% within 2040. A great fraction of this electrical energy will be managed by power semiconductors, during either its generation, transmission, or final usage. This critical aspect of the power management, sometimes overlooked, must be taken into great consideration, since advanced power- and high-frequency electronics devices and systems can make traditional and renewable energies more efficient, with great benefits on the reduction of CO_2 emissions and global warming.

In this context, for many decades silicon has dominated the world of electronic devices. However, Si has reached its limits in terms of power density, operation frequency and temperature, as well as energy efficiency in energy conversion systems. Hence, since the 1980s intensive efforts have been dedicated to *wide band gap (WBG) semiconductors*, and in particular silicon carbide (SiC) and gallium nitride (GaN), resulting in power- and high-frequency devices with superior performances (frequency- and temperature-operation, power handling, efficiency, etc.), now commercially available in a large variety of products (SiC Schottky diodes and JBS, SiC MOSFETs, GaN HEMTs, etc.).

In fact, owing to their outstanding properties such as the wide band gap and high critical electric field, these materials can enable the fabrication of high-voltage devices with significantly lower on-resistance, operating at higher frequencies and temperatures with respect to Si devices.

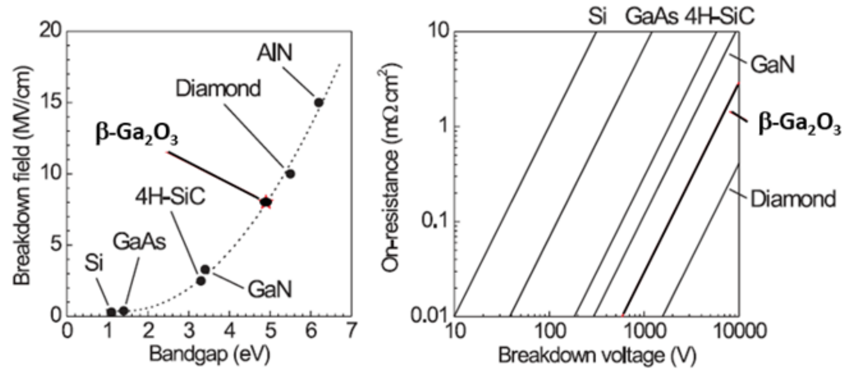

Fig. 7: Breakdown-voltage vs energy gap for the most common WBG and UWBG semiconductors with respect to Si and trade-off of the on-resistance vs breakdown voltage.

Important application domains of WBG semiconductors are the automotive sector, e.g. for various DC/DC or AC/DC converters in electric and hybrid vehicles (EV/HEV), the photovoltaics (PV) DC/AC converter, the data centers, etc. As an example, considering only the strategic sector of automotive, in the next years, the semiconductor power-device market in EV/HEV is expected to grow with a CARG of 25.9%. This market will be dominated by Si-IGBT and SiC MOSFETs, and will see the pervasive introduction of GaN HEMTs.

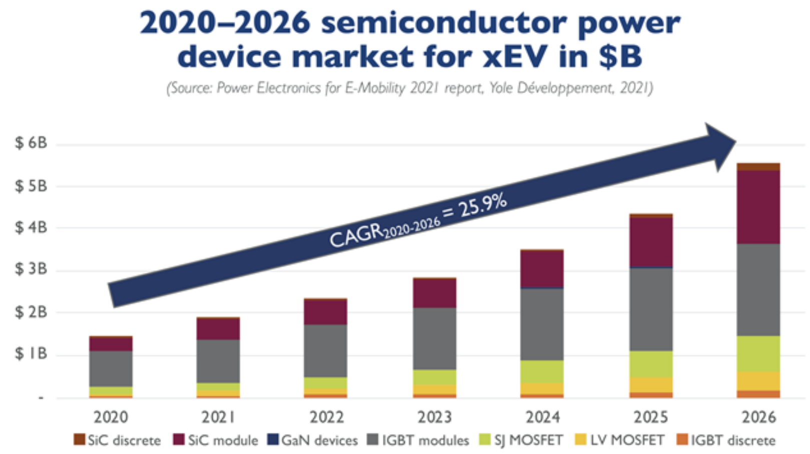

Fig. 8: Semiconductor power device marked forecast for electrified automotive 2020-2026 (Source Yole 2020).

It has been estimated that the pervasive application of WBG semiconductors and other advanced materials and innovation technologies in modern electronics will lead to a significant global energy saving in different fields, as shown below.

Energy saving (TWh/year) obtained in different application fields, by replacing Si with WBG technology *(Source: Power Electronic Conversion Technology Annex – 2020)*	
Applicaion Field	**Energy Saving (TWh/year)**
Road Transport Electrification	11.7
Wind Energy Generation	35.6
Photovoltaics Energy Generation	10.3
Power Supply (AC-DC)	7.8
Data Centers	28.4

In spite of these great progresses in SiC and GaN transistors done in the last two decades, several technological issues are still open. Examples of topics to be addressed are:

- Novel processes for on-resistance reduction in the medium voltage devices for automotive applications
- New SiC epitaxial materials (also p-type doped) on 200mm substrates
- Alternative low-cost SiC wafers solutions, e.g. poly-SiC
- Novel reliable high-k dielectrics for 4H-SiC MOSFETs and CMOS and GaN-HEMTs
- Vertical GaN devices architectures, e.g., based on emerging bulk GaN materials or novel AlN substrates
- Advanced normally-off RF GaN HEMTs technology, for mobile phones handset applications

To face all these issues, and open also new perspectives in other fields, significant efforts are still required to develop **advanced materials** and related ***key enabling technologies (KETs)***, e.g.considering the possibility to explore less mature semiconductors like cubic polytype of SiC (3C-SiC), low-cost polycrystalline SiC, lattice-matched InAlN or InAlGaN materials for RF heterostructures, bulk gallium nitride (GaN) or gallium oxide (Ga_2O_3), aluminum nitride (AlN) or diamond. These three latter are typically regarded as *ultra-wide-band-gap (UWBG) semiconductors* since their energy gap is larger than 4 eV. These semiconducting materials have not reached yet an adequate crystalline quality as that of Si, SiC or GaN, i.e. suitable for electronic applications. Moreover, also some key processing steps for power and high-frequency devices still need to be developed. However, they are particularly interesting as they can enable additional improvements in other fields, such as optoelectronic devices, sensors, MEMS, etc. Among UWBG materials, gallium oxide (Ga_2O_3) is particularly attracting, since high growth rates are possible and the wafer diameter can be scaled quickly (and will reach soon 150mm). In addition, Ga_2O_3 is potentially a cheap material, but to date the marked is totally dominated by few material players mainly in Japan (Kyma Technologies, TAMURA Corp., FLOSFIA Inc., etc.). A renowned supplier of automotive systems, DENSO Corporation, has recently partnered with a tech startup FLOSFIA to come up with a device of next-generation power semiconductor for electric vehicles. In spite of its huge potential, there are some technological concerns that require significant research and innovation efforts, such as inferior thermal performance (i.e., lower thermal conductivity), lack/difficulty of p-type doping, and the possibility to grow heterostructures with GaN-based materials. In fact, Ga_2O_3 semiconductor market size was estimated to be $8.7M in 2020, growing at a CAGR of 66.9% during the forecast period 2021-2030, being this growth driven by the increase in academic institutes' research and development activities. Today, a variety of devices based on Ga_2O_3 have been demonstrated as a proof of concept, also including low-cost solutions based on the transfer of thin Ga_2O_3 films onto other substrates. Very promising is also the possibility of a heterogeneous integration of Ga_2O_3 either with GaN or even with large area silicon wafers. However, the high price of the bulk material, as well as some open technological issues, still hinder its practical application on a large scale. In this context, while some competences in the material growth are present in Italy (e.g. University of Parma), there is still a lack of know-how on the KETs developments for Ga_2O_3-based devices.

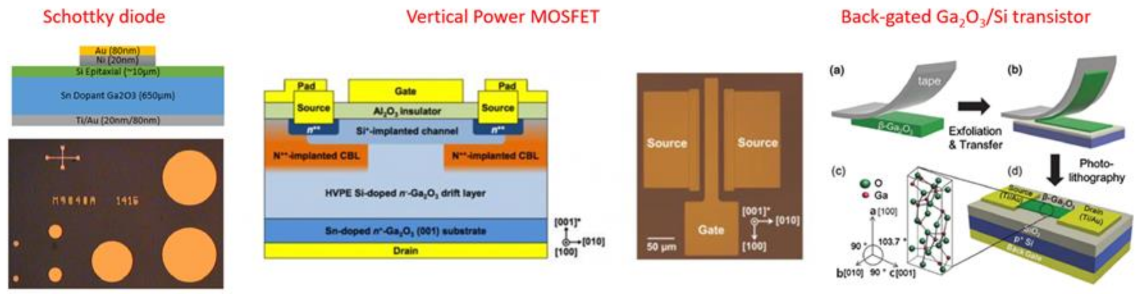

Fig. 9: Examples of Ga_2O_3-based devices: Schottky, MOSFET and back-gate transistor.

On the other hand, modern electronics is moving towards advanced materials with a low-dimensionality, being graphene the most popular one, which exhibits exceptional properties in terms of electron mobility and thermal conductivity. The *integration of two-dimensional (2D) materials*, such as graphene or MoS_2 (Molybdenum Disulfide) with hexagonal WBG semiconductors has been recently considered, with the aim to improve the performances of GaN-based optoelectronics or high-power devices. A technological challenge in this field is represented by the integration of *novel insulating materials* (e.g. *hexagonal boron nitride h-BN*) to improve the channel mobility in transistors based on 2D materials. Furthermore, new device concepts and new applications (also in the fields of photonics, sensors, or quantum technologies, etc.) can arise in future from the combination of the outstanding physical properties of these two classes of materials. As an example, besides the use of 2D materials as transparent electrodes in optoelectronic devices (LEDs), owing to its high mobility and thermal conductivity, graphene can be a solution as a channel material for high-frequency RF transistors and for self-heating problems in GaN-based high-power HEMTs, or can be used for new devices' concepts such us hot electron transistors.

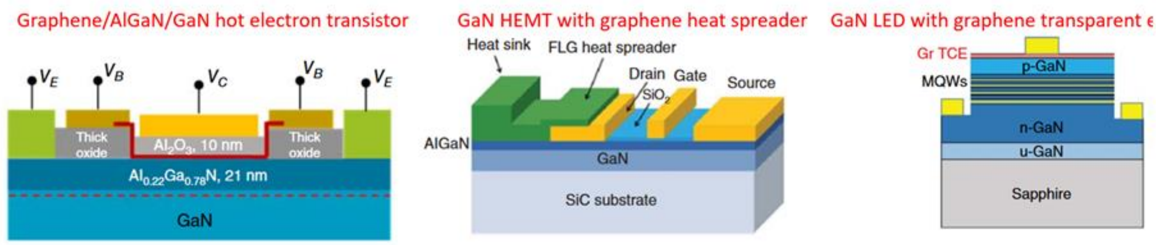

Fig. 10: Examples of devices fabricated integrated 2D materials with WBG semiconductors SiC and GaN.

Moreover, the limitations coming from the zero-band-gap of graphene can be overcome by exploring alternative 2D materials with a suitable bandgap, such as the transition metal dichalcogenides (TMD), which are attracting a great interest for the next generation of thin film transistors for logic and/or high frequency applications. Among them, MoS_2 is very interesting, due to its natural abundance and high stability at ambient conditions, and its tunable band gap and doping obtainable upon changing the number of grown layer and/or the post-deposition processes (e.g. annealing, plasma, etc.).

All these trends have been confirmed by worldwide academic and industrial in the *IEEE International Roadmap for Devices and Systems 2020*, for the "Smart Energy" sector. Moreover, the development of new technologies for power- and high-frequency electronics, smart energy and sensing, based on compound semiconductor materials (instead of silicon), and devices suitable for more advanced chips, have been defined by France, Germany, Italy and UK as key assets of the *Important Project of Common European Interest ("IPCEI")* to support research and innovation in microelectronics.

In order to face these challenges, dedicated facilities, equipped with state–of–the–art clean rooms and specific equipment, are needed to address the complexity of the new materials and devices issues, which are significantly different from the consolidated Si technology. Hence, several infrastructures have been created in Europe to bridge the fundamental research with the technological transfer to the productive world. Examples of large R&D infrastructures already present overall in Europe are the, MINATEC (France), IMEC (Belgium), Fraunhofer Institute and IHP (Germany). These infrastructures are typically located in the proximity of big semiconductor factories e.g. STMicroelectronics, ON-Semiconductors, Infineon. In these ecosystems, these infrastructures are able to provide great benefits to the entire value chain, by the development of innovative devices technologies in the field of micro- and nano-electronics. The MINATEC innovation campus enrolls about 3000 researchers and is equipped with 13,000 m² of clean room space. An international hub for micro and nanotechnology research, the MINATEC campus is a unique R&D facility in Europe and takes benefit from the active role played by CEA–Leti, a recognized center for cutting-edge innovation. IMEC is an R&D hub for nano- and digital technologies, established as a leading research site for advanced CMOS scaling. Its unique infrastructure includes a 300mm semiconductor pilot line with more than 5000 scientists from over 95 countries world-wide, in an ecosystem of more than 600 world-leading industry partners and a global academic network. The Fraunhofer Institute facilities are placed in Germany in different locations, and are characterized by a high flexibility in wafer material and size. Silicon wafers (150 mm–200 mm) are handled by default, but further diameters and materials (e.g. SiC) are processed on request. The Leibniz Institute for High Performance Microelectronics (IHP) is one of the internationally recognized competence centers for silicon-germanium technology. In this center, cutting-edge research and development into silicon–based systems, high-frequency circuits and technologies for wireless and broadband communication is carried out. Fraunhofer and IHP represent a transition between basic research and application-oriented research. Clearly, all these infrastructures are dedicated either to large area Si-based digital electronics, or to mature WBG semiconductors materials (i.e., 4H–SiC or GaN–on–Si), but they neither address the aforementioned new technologies beyond SiC and GaN, nor their integration with novel 2D materials. Moreover, also smaller R&D infrastructures (typically grown as spin-off of Universities or Research Centers), have been created in Europe to address specific technological issues in micro- and nano-electronics (e.g. ICTS, AMO GmbH, NamLab, etc.).

In this context, although the microelectronics research activity in Italy is state–of–the–art and several excellent competence centers are present at University and CNR Institutes, *the country is not equipped yet with single-site R&D infrastructures facilities comparable to the aforementioned European ones*. Consequently, it is not always possible, for the Italian Research Institutions, to **bring the advanced materials and technologies from a basic research to high TRL levels (6-7)**. Hence, in order to maintain a high innovation character and competitiveness of both public and private research in Italy, the aforementioned advanced technologies based on novel materials must be developed in a unique environment, through the establishment of a **dedicated infrastructure with versatile equipment**. The close proximity of the infrastructure with the semiconductor industry is obviously a clear benefit to attain the **convergence of multiple competences** and technologies coming from Si world and going beyond Si, and to rapidly **identify the most promising source of innovations**, which can sustain the Italian industry with **new IP development and technological transfer**.

For those reasons, we propose the creation of a new infrastructure dedicated to these innovative technologies in Italy, **located in the microelectronics hub of Catania**, which is an area considered a case of National and International importance and, hence, the most fertile place in Italy for developing beyond-silicon micro- and nano-electronics. As deduced by a preliminary feasibility analysis conducted by CNR, some companies already manifested a strong interest towards this initiative (*see attached letters of interest*).

The ***High Performance Microelectronics Infrastructure (HPMI)*** will be equipped with **a class 10 clean–room**, extending above 1000 m^2 (expandable in the future), conceived to address specific issues limiting the current performance of state–of–the–art SiC and GaN devices and to develop the KETs for next generation of advanced materials, bringing these technologies from the basic research to the demonstration of devices operable in an industrial or application environment (TRL 6-7). The infrastructure will be based on a **"front-end pilot line approach"**, with *highly flexible equipment* enabling *processing of new materials* of *different wafer size*.
The focus of the activities will be on **advanced materials for energy efficient micro– and nano–electronics** beyond–silicon technologies. In particular, HPMI will operate in strong synergies with the medium-large microelectronics industry, putting in place different strategies, such as: (i) the development of novel materials and processing steps to improve the current SiC and GaN devices performances and reliability; (ii) the exploration of emerging ultra-wide-band-gap (UWBG) semiconductors (e.g. Ga_2O_3, AlGaN, AlN, diamond…) to go beyond the limits of SiC and GaN; (iii) the integration of two-dimensional (2D) materials (e.g. graphene, MoS_2, etc.) and novel dielectrics on WGB semiconductors to increase their functionalities and open new applications also in other fields, e.g. THz electronics, optoelectronics and sensing.

The clean room will be located in the microelectronics hub of Catania, the only place in Italy possessing all the competences to entirely cover the scientific/technological aspects targeted by the initiative.
To guarantee the financial feasibility and the foreseen time-schedule of the initiative, the most suitable approach is to *create the infrastructure in a context where high-tech buildings/facilities are already present*. In particular, the availability of the clean room will enable to optimize the project execution and concentrate the investment in equipment and digital tools. In this respect, some of the industrial stakeholders present in the Etna Valley area have the capability to realize in a short time in their premises such a facility and are willing to grant the use of the clean room spaces for HPMI. Obviously, the implementation of this action will be done contextually with the "public tender" for the selection of the public-private-partners, as described in sections B2.2 and B2.4.

The clean room will be organized in areas of different cleanliness (ISO4 – ISO6) and divided in different bays for (i) *lithography*; (ii) *deposition & materials growth*; (iii) *etching*; (iv) *annealing*; (v) *doping*; (vi) *grinding & polishing*. In addition, there will be also an area (vii) for *in-line inspection and metrology*, with basic tools for the optical and topographic control of the structures, as well as a preliminary electrical characterization of the fabricated test patters.

The clean room of HPMI will be equipped with a variety of tools to cover the entire processes chain for prototypes fabrication. The list of tools is reported in the table:

List of HPMI Equipment
Lithography
Direct Laser Lithography
Electron Beam Lithography
Spin coating/developing/pre- and post-bake
Cleaning and wet etch
Wet chemical benches
Spin dryers
Depositions & Materials Growth
Plasma-Enhanced CVD system
Low Pressure CVD system
Electron Beam Evaporator
DC/RF Sputter Deposition System
Atomic Layer Deposition
MOCVD reactor for oxides
CVD reactor for large area 2D materials growth
LP-CVD reactor for poly SiC
CVD reactor for 200mm SiC epitaxy
Etching
Inductively Coupled Plasma (ICP) dry etcher
Annealing
Rapid Thermal Annealing (RTA) system
High-temperature furnace for SiC dopant activation
High-temperature oxidation furnace for SiC
Horizontal furnaces (multi-tube annealing, ox, polySi, SiN, etc.)
Doping
Ion-implanter with hot implantation capability
Grinding & Polishing
Chemical Mechanical Polishing (CMP)
In-line Inspection and Metrology
Optical microscope
Profilometer
Spectroscopic Ellipsometer
Non-contact sheet resistance and Hall effect measurements
Hg-probe system
Probe station for in-line wafer-level testing

In more detail, the lithography will be covered by a direct writing lithography, enabling high versatility ("mask-less") with fast exposure times (large areas possible), and by an e-beam lithography for the development of sub-micrometric structures. Due to the specific focus on advanced materials, the acquisition of several deposition and growth tools is foreseen, In fact, besides the metal and dielectric deposition systems (evaporation, sputter, PECVD, LPCVD, ALD), this sector will be characterized by a strong component of material growth. In fact, four CVD reactors will be acquired for the materials growth (SiC, poly-SiC, oxides like Ga_2O_3, 2D materials). A reactor for nitrides is not foreseen, as will be already available within the infrastructure Beyond-Nano. Chemical Mechanical Polishing (CMP) will be used to refine the surfaces of the epi-grown materials. Etching will be covered by standard wet-etching and ICP dry etching (enabling sot-etching for low-damage of the channel regions). The annealing processes will be also covered by a variety of equipment, to fulfil the requirements of beyond-silicon technologies. Hence, besides the conventional furnaces and rapid thermal annealing (RTA) tools, high-temperature annealing (1600-2000°C) and high-temperature oxidation (1300°C) systems dedicated to SiC technology will be acquired.

Finally, ion implantation doping (medium energy) is foreseen, and equipped with hot-implants up to 700°C. Finally, some basic inspection and metrology tools will be acquired to allow a quick optical morphological and electrical testing of the materials, processes and devices.
The major criterion for the choice of the equipment will be ***versatility over throughput***. Hence, the tools will be chosen considering prevalently the need of developing KETs in new semiconductor materials, and must be able to process wafers of different diameter (50, 100, 150 and 200mm) as well as samples of irregular size and shape.
As can be seen, besides typical front-end tools, also CVD reactors for advanced materials growth are foreseen. This will require additional design and technical expenses to adapt to the reactors some area of the infrastructure. Back-end equipment was not considered yet, since basic processes of wafer dicing and simple packaging can be eventually commissioned outside (e.g. basic back-end labs are available in Catania site of STMicroelectronics).
Noteworthy, the infrastructure will be equipped with a customized *"assets tracking" software platform*, providing the capability to **monitor remotely all the interconnected tools**, the status of all the critical assets and assess their impact on the activities. In particular, this software will provide the following information: (i) **preventive maintenance or safety inspections** of the equipment; (ii) accurate **inventory** of the available consumable materials and equipment, (including details like the firmware/software used, accessories, configuration and components, available spare parts, etc.); (iii) **automated tracking of the samples and processes** (allowing real-time automatic data collection from the tools).
Using this **digital approach**, it will be possible to prevent labor wastage, and also avoid inadvertent mistakes or inefficiencies in the fabrication process itself.
Moreover, a catalogue of methods, data, facilities and competences will be made available (and regularly updated) on a **web-platform**, used also for *proposal application*, in order to provide the necessary information to potential users and stakeholders. The realization of the entire software platform will be commissioned to a specialized company. For this purpose, the acquired tools will be equipped with adequate Ethernet protocols, in order to enable their interconnection and data management. The development of this platform has been considered in the costs.

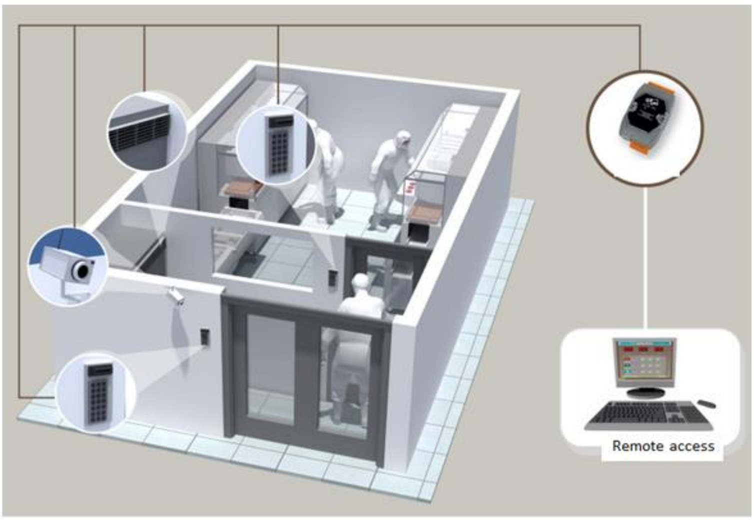

Fig. 11: Schematic of the clean room management by web-based software platform.

Finally, it must be pointed out that a large part of the **advanced technologies** targeted within HPMI will be at the basis high-frequency and low power consumption devices, which will find applications in *big data centers* (e.g. WBG-based converters), *wireless communication technologies and sensors* (e.g. novel 2D/WBG heterostructures for 5G and 6G technology), etc. Hence, this will be an additional key **contribution to the digital transition**.
In conclusion, the mission and organization of HPMI are fully coherent with the *Intervention field 6* of the Recovery and Resilience Facility (RRF) (Investment in digital capacities and deployment of advanced technologies), and obeys to the constraint 055 (Other types of ICT infrastructure (including large-scale computer resources/equipment, data centres, sensors and other wireless equipment)) reported in Annex VII of Reg. (EU) 2021/241.

B.2. **Governance model**

B.2.1. Infrastructure and operational management

The HPMI is a single-site infrastructure, geographically localized in the microelectronics hub of Catania. The HPMI will be a Special Purpose Vehicle (SPV), regulated in compliance with art. 17 of Leg. Decree 175/2016, with a legal status of a limited company and a governance structure with clear responsibilities and reporting vertical lines. This governance structure will be mainly composed by a General Assembly, a Scientific Advisory Board, a Board of Directors, an Executive Director, and an Infrastructure Manager.

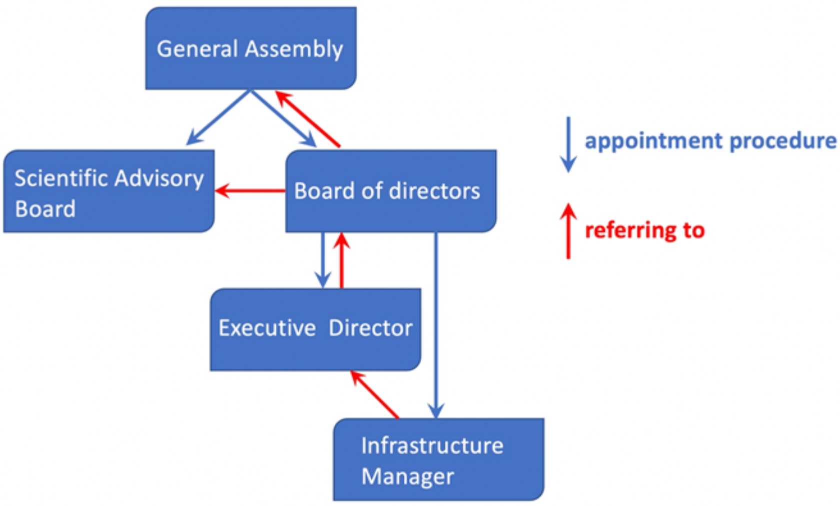

Fig. 12: Governance schematic model of HPMI.

The shareholders **General Assembly (GA)** appoints members of the Scientific Advisory Board and Board of Directors (this latter composed by a maximum of 5 components). **Board of Directors (BD)** is the decision–making body of HPMI and it nominates the **Executive Director (ED)** and the **Infrastructure Manager (IM)**. The Executive Director is the legal representative of HPMI and will lead and administrate the HPMI legal entity, supported by an administrative and management staff. The Infrastructure Manager has the overall responsibility of the use of the clean room equipment, the use of the financial resources and the access and safety in the infrastructure. Besides having a good technical knowledge of the infrastructure, itself, he, or she, must have a wide experience in the research areas and topics addressed by HPMI and experience in project management involving both private and public beneficiaries. Hence, he/she is selected among well recognized personalities of the international scientific community. The IM must be able to start designing and then, after discussion-approval by the governance, implement the business development and fundraising strategy so to assure the long-term sustainability of the innovation infrastructure. The IM operates according to the strategic programs and budgets deliberated by the Board of Directors. In particular, the BD defines the HPMI R&D activities roadmap, approves the budget of HMPI and decides on new acquisitions, approves the participation in new research projects and EU proposals, evaluates eventual requests of adhesion to the PPP of other partners, etc. The BD operates with the support of the *internal administrative and technical organization* to address all the administrative issues, submit new proposals for funding acquisition, takes care of the equipment maintenance, etc. The **Scientific Advisory Board (AB)** is an independent body composed by 5 distinguished scientists or experts in the fields of semiconductor materials and devices, nominated by the GA. The AB advises the BD with regards to the implementation of the HPMI scientific and innovation programs and long-term roadmap.

B.2.2. PPP operation

The modality of the creation of the PPP will be the recourse to a **"public tender" to choose the private partners** of HPMI, in compliance with d. Lgs. no. 50/2016 (Italian Code for Public Contracts). More specifically, the open call will be mainly addressed to all the private partners (e.g. companies specialized in semiconductor devices manufacturing, semiconductor equipment providers/developer, companies specialized in clean room fabrication or software development for clean room managements, etc.) that are potentially interested in the implementation of the HPMI, providing full guarantees of the impartiality of the selection process. For this purpose, the procedure will be done through adequate advertising of the invitation to formulate the contribution to the HPMI project. The applicants will be also encouraged to develop or apply **innovative technical solutions**, suited to the particular needs of the infrastructure, even if they are not clearly specified in this proposal.
In particular, one or more of **the following contributions to the initiative are expected from the potential private partners** and will be explicitly mentioned in the tender:

- Willingness of economic operators to co-fund the investment for the project implementation.
- Realization and grant to use a clean room class 10, with an extension of about 1000m^2, located in the microelectronics hub in Catania, where all the equipment will be installed, in compliance with the Gannt Chart of the project reported in section B4.
- Providing or development equipment for semiconductor materials growth or devices processing, useful for the activities of HPMI (i.e. not necessarily restricted to those reported in section B1).
- Development of customized software for the digitalization of the infrastructure, at least with the functionalities generally described in section B1.

B.3. Budget plan

For the project implementation, the following **direct costs** are envisaged (see also section B1 for additional details):

Expenses related to infrastructure manager (IM) and other executive personnel *(estimated as the cost of the IM during the three year of project implementation)*	**1.000.000 €**
Scientific instrumentation, research equipment and machinery and relative accessories, turnkey *(estimated on the basis of a preliminary market analysis)*	**31.770.000 €**
Direct Laser Lithography	**1.000.000 €**
Electron Beam Lithography	**2.200.000 €**
Spin coating/developing/pre- and post-bake	**300.000 €**
Wet chemical benches	**500.000 €**
Spin dryers	**200.000 €**
Plasma-Enhanced CVD system	**1.800.000 €**
Low Pressure CVD system	**1.800.000 €**
Electron Beam Evaporator	**1.200.000 €**
DC/RF Sputter Deposition System	**1.200.000 €**
Atomic Layer Deposition	**1.000.000 €**
MOCVD reactor for oxides	**1.400.000 €**
CVD reactor for large area 2D materials growth	**1.400.000 €**
LP-CVD reactor for poly SiC	**1.500.000 €**
CVD reactor for 200mm SiC epitaxy	**3.000.000 €**
Inductively Coupled Plasma (ICP) dry etcher	**1.300.000 €**
Rapid Thermal Annealing (RTA) system	**1.000.000 €**
High-temperature furnace for SiC dopant activation	**1.000.000 €**
High-temperature oxidation furnace for SiC	**1.000.000 €**
Horizontal furnaces (multi-tube annealing, ox, polySi, SiN, etc.)	**1.500.000 €**
Ion-implanter with hot implantation capability	**4.270.000 €**
Chemical Mechanical Polishing (CMP)	**500.000 €**
Optical microscope	**350.000 €**
Profilometer	**250.000 €**
Spectroscopic Ellipsometer	**350.000 €**
Non-contact sheet resistance and Hall effect measurements	**450.000 €**
Hg-probe system	**300.000 €**
Probe station for in-line wafer-level testing	**1.000.000 €**
Technical installations (Hook-up) *(estimated as forfeit of 10% of the total equipment cost)*	**3.177.000 €**
Software licences and patents *(estimated cost of the customized Clean Room control software developement, including materials and computer resources to run the software)*	**840.000 €**
Design and other technical expenses *(e.g., design & project of area suitable for reactors installation, in-line inspection and metrology area, safety tools, consumables, etc.)*	**600.000 €**

A summary of the eligible costs, including the indirect costs, is reported in the table:

Eligible cost (Art. 7 of the call for proposal)	**Costs €**		
	Not to be located in Mezzogiorno Regions	To be located in Mezzogiorno Regions	**Total**
a. Expenses, even if not accounted for as tangible and intangible investments, related to one highly qualified infrastructure manager and other executive personnel (managers) in charge of the services offered by the Infrastructure	0	1000000	1000000
b. Scientific instrumentation, research equipment and machinery and relative accessories, turnkey	0	31770000	31770000
c. Technical installations strictly connected to the functionality of equipment and machinery	0	3177000	3177000
d. Software licences and patents	0	840000	840000
e. Buildings and land (including built land) not exceeding 10% of the total cost of the project. For sites in a state of decay and for those previously used for industrial purposes that include buildings, this limit is increased to 15%	0	0	0
f. Rehabilitation, renovation, redevelopment and expansion of buildings if strictly necessary as to the functionality of the Infrastructure	0	0	0
g. Design cost and other related technical expenses	0	600000	600000
h. Indirect costs, forfeit (up to a maximum of 7% of the other project costs)	0	1913000	1913000
Total	0	39300000	39300000

B.4. Project time schedule

The activities will be implemented following a well-detailed time-schedule. The very first action will be the appointment of the Infrastructure Manager (IM), which will be completed within 6 months. After his/her appointment, from M7 the IM will coordinate an update of the market survey and the definition of the final technical requirements for the tools. The timeline of the acquisitions of the tools has been defined considering their complexity, and organized in such a way to distribute these actions during the entire project duration. After its delivery, each tools will be connected to the facilities (hook-up) and tested in the clean room of HPMI. The last 18 months will include the testing of the entire pilot-line, both in terms of customized control software and by running simple flow-charts until the prototypes fabrication.

In the following, a Gannt Chart of the activities is reported:

		M1	M2	M3	M4	M5	M6	M7	M8	M9	M10	M11	M12	M13	M14	M15	M16	M17	M18	M19	M20	M21	M22	M23	M24	M25	M26	M27	M28	M29	M30	M31	M32	M33	M34	M35	M36
Obj.1	Appointment of the Infrastructure Manager (M1-M6)																																				
Obj.2	Clean Room Realization (M1-M20)																																				
	Equipment acquisition																																				
Obj. 3	Direct Laser Lithography (M7-M21)																																				
Obj. 4	Electron Beam Lithography (M12-M32)																																				
Obj. 5	Spin coating/developing/pre- and post-bake (M7-M20)																																				
Obj. 6	Wet chemical benches (M7-M20)																																				
Obj. 7	Spin dryers (M7-M20)																																				
Obj. 8	Plasma-Enhanced CVD system (M12-M32)																																				
Obj. 9	Low Pressure CVD system (M12-M32)																																				
Obj. 10	Electron Beam Evaporator (M8-M28)																																				
Obj. 11	DC/RF Sputter Deposition System (M10-M33)																																				
Obj. 12	Atomic Layer Deposition (M14-M33)																																				
Obj. 13	MOCVD reactor for oxides (M14-M36)																																				
Obj. 14	CVD reactor for 2D materials (M14-M32)																																				
Obj. 15	LP-CVD reactor for poly SiC (M14-M33)																																				
Obj. 16	CVD reactor for 200mm SiC epitaxy (M14-M36)																																				
Obj. 17	Inductively Coupled Plasma (ICP) dry etcher (M10-M30)																																				
Obj. 18	Rapid Thermal Annealing (RTA) system (M10-M20)																																				
Obj. 19	High-temperature furnace for SiC dopant activation (M10-M34)																																				
Obj. 20	High-temperature oxidation furnace for SiC (M10-M34)																																				
Obj. 21	Horizontal furnaces (multiple tubes) (M8-M27)																																				
Obj. 22	Ion-implanter with hot implantation capability (M12-M36)																																				
Obj. 23	Chemical Mechanical Polishing (CMP) (M15-M29)																																				
Obj. 24	Optical microscope (M9-M20)																																				
Obj. 25	Profilometer (M9-M24)																																				
Obj. 26	Spectroscopic Ellipsometer (M14-M30)																																				
Obj. 27	Non-contact sheet resistance and Hall effect measurements (M19-M36)																																				
Obj. 28	Hg-probe system (M19-M34)																																				
Obj. 29	Probe station for in-line wafer-level testing (M19-M34)																																				
Obj. 30	Digitalization and Testing of the pilot-line (M12-M36)																																				

B.4.1. Intermediate objectives

Obj.1 / Appointment of the Infrastructure Manager
Start month: M1; duration (6 months): **M1-M6**

<u>Summary of the activities envisaged</u>

At the project start, the Infrastructure Manager (IM) will be appointed with a public selection. The candidates must have a well-recognized international scientific experience in the field of advanced semiconductor materials and devices, and have experience in project management. This action will be completed within 30.06.2023.

Obj.2 / Clean Room Realization
Start month: M1; duration (36 months): **M1-M36**

<u>Summary of the activities envisaged</u>

The clean room will be made available in the microelectronics hub of Catania by one of the industrial stakeholders, which will grant its use for HPMI. Hence, the cost of the clean room realization is not explicitly reported in the budget plan, but only the hook-up costs of the equipment and other design and technical expenses are considered. The clean-room will cover an area of approximately 1000m² with cleanliness class from ISO 4 (in the Yellow Room) to ISO 6 in the Grey Area (for the facilities). The clean-room will be equipped with HEPA fan filter unites and with all the facilities needed by the tools (e.g., distributed process gases, compressed dry air, cooling water, exhaust connections to the scrubber, electric power supply, etc.). The clean-room will have controlled temperature and humidity conditions and will be equipped with perforated tiles floor, automatic doors, viewing windows, glass walls, sprinkler heads / fire suppression, Wi-Fi / network access, etc.

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Equipment acquisitions

Obj.3 / Direct Laser Lithography
Start month: M7; duration (15 months): **M7-M21**

Obj.4 / Electron Beam Lithography
Start month: M12; duration (21 months): **M12-M32**

Obj.5 / Spin coating/developing/pre- and post-bake
Start month: M7; duration (14 months): **M7-M20**

Obj.6 / Wet chemical benches
Start month: M7; duration (14 months): **M7-M20**

Obj.7 / Spin dryers
Start month: M7; duration (14 months): **M7-M20**

Obj.8 / Plasma-Enhanced CVD system
Start month: M12; duration (21 months): **M12-M32**

Obj.9 / Low Pressure CVD system
Start month: M12; duration (21 months): **M12-M32**

Obj.10 / Electron Beam Evaporator
Start month: M8; duration (21 months): **M8-M28**

Obj.11 / DC/RF Sputter Deposition System
Start month: M10; duration (24 months): **M10-M33**

Obj.12 / Atomic Layer Deposition
Start month: M14; duration (20 months): **M14-M33**

Obj.13 / MOCVD reactor for oxides
Start month: M14; duration (23 months): **M14-M36**

Obj.14 / CVD reactor for 2D materials
Start month: M14; duration (19 months): **M14-M32**

Obj.15 / LP-CVD reactor for poly
Start month: M14; duration (20 months): **M14-M33**

Obj.16 / CVD reactor for 200mm SiC epitaxy
Start month: M14; duration (23 months): **M14-M36**

Obj.17 / Inductively Coupled Plasma (ICP) dry etcher
Start month: M10; duration (21 months): **M10-M30**

Obj.18 / Rapid Thermal Annealing (RTA) system
Start month: M10; duration (11 months): **M10-M20**

Obj.19 / High-temperature furnace for SiC dopant activation
Start month: M10; duration (25 months): **M10-M34**

Obj.20 / High-temperature oxidation furnace for SiC
Start month: M10; duration (25 months): **M10-M34**

Obj.21 / Horizontal furnaces (multiple tubes)
Start month: M8; duration (20 months): **M8-M27**

Obj.22 / Ion-implanter with hot implantation capability
Start month: M12; duration (25 months): **M12-M36**

Obj.23 / Chemical Mechanical Polishing (CMP)
Start month: M15; duration (15 months): **M15-M29**

Obj.24 / Optical microscope
Start month: M9; duration (12 months): **M9-M20**

Obj.25 / Profilometer
Start month: M9; duration (16 months): **M9-M24**

Obj.26 / Spectroscopic Ellipsometer
Start month: M14; duration (17 months): **M14-M30**

Obj.27 / Non-contact sheet resistance and Hall effect measurements
Start month: M19; duration (18 months): **M19-M36**

Obj.28 / Hg-probe system
Start month: M19; duration (16 months): **M19-M34**

Obj.29 / Probe station for in-line wafer-level testing
Start month: M19; duration (16 months): **M19-M34**

Summary of the activities envisaged in Obj. 3-29

The objectives from Obj. 3 to Obj. 29 consist in the acquisition and installation of the tools inside the clean room. Hence, this action will start after the appointment of the IM. One objective for each tool is considered, whose duration will comprise an update of the market survey to define the cost and specification of the tool, and the implementation of the administrative procedures for its acquisition (e.g. public tender). The objectives are organized in a logical time-sequence and with duration that depend on the complexity of the equipment. Each objective is completed with the installation and testing of the technical specifications of the tool. General details on the characteristics of the tools and criteria for their choice are reported in section B1 of the proposal.

Obj. 30 / Digitalization and Testing of the pilot-line
Start month: M12; duration (25 months): **M12-M36**

Summary of the activities envisaged

The final objective is to equip the pilot-line with its software platform interconnecting the tools and to test the pilot-line by running single processing steps, simple flow-charts, up to the fabrication prototypes. Hence, this action will start at M12 and will be continuously implemented during the acquisition of the single tools. A customized asset tracking software will be developed by a specialized company and tested to manage all the operations of the infrastructure, using appropriate protocols. For process testing, at the beginning, after the acquisition of the first tools, single steps like lithography or metal depositions will be tested, and then integrated in simple flow-charts for test-structures. Finally, when more complex equipment will be acquired (like dielectric depositions, plasma etch, ion implantation, etc.) some prototype will be realized, focusing first on more consolidated SiC or GaN processes.

B.4.2. Timeframe envisaged for the implementation of the procedure aimed at setting up a PPP

In order to set up the PPP for HPMI the following time schedule is envisaged. In the last months, by developing the project idea, a preliminary feasibility analysis of the potential private partners interested in the initiative has been already done and the proposal contents have been tuned accordingly. Then, as already specified in section B.2.2, an open call will be used to select the private partners that will contribute in the implementation of the project participating in the PPP. The call will be open in a phase subsequent to the proposal presentation. The private subjects will be selected among them that have manifested their interest in the call and can participate with their technical or/and financial contribution in the initiative. The timeframe from the call opening until the selection of the partners will last 60days. After their selection, the partners will be involved in a negotiation phase to define the conditions of the PPP and sign the contract, whose duration typically last about 4 months. The signature of the PPP contract is expected to occur before the project starting date**.**

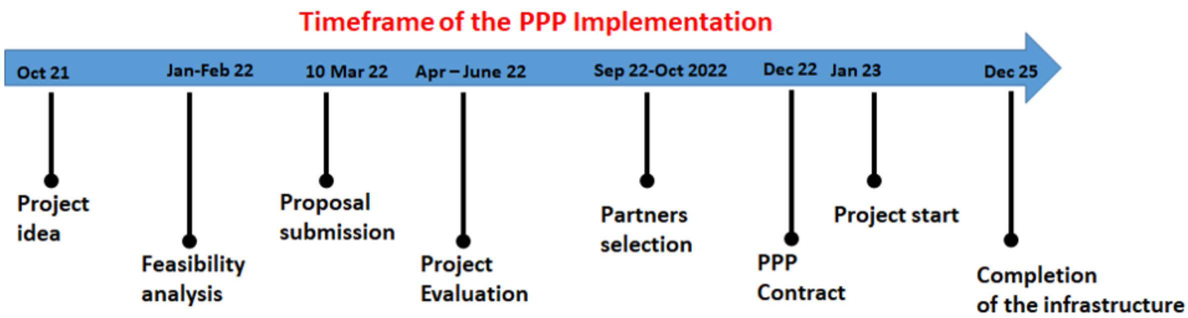

Fig. 13: Expected timeframe of the implementation of the public-private-partnership

B.5. Promotion of knowledge transfer and business creation activities.

Within its innovation strategy, HPMI will promote the importance of improving **knowledge transfer** between public research and industry, including also (when possible) transfer to the wide scientific community and the civil society. In fact, the daily interaction of public research with industry in the same environment will favour exchanges of skills, knowledge and good practices and encourage joint programs. **Communication and dissemination** of the activities will be a conventional mean of spread the knowledge to the research community as well as to the wide public. Hence, the publication of scientific results, as well as their communication to specialized conferences or to non-specialists magazines will be envisaged. The need to publish and make results freely available is often considered as incompatible with industry's need to keep information confidential and protected by IP rights (e.g. patents). However, in the microelectronic hub of Catania, CNR has a long-standing mutual experience with the local industrial partners (e.g. ST, LPE, Enel Green Power, etc.) in understating and professionally managing the **IP protection**. Hence, within the infrastructure the public-private-partnership will create an **IP Management Committee (IPMC)**, to identify and manage knowledge deserving protection (i.e. patents) or resources with business potential, i.e. how best to take a new idea into market, ensuring appropriate resources (funding, support services, etc.) to make it happen. In addition, HPMI will also support the creation of ***start-ups*** under its umbrella, combining technical know-how, state-of-the-art equipment and innovation expertise, together with a network with other research centers and alliances with industrial partners. Hence, one of the missions of HPMI will be to provide individually tailored encouragement and assistance to employees and/or external users who decide to set up a business using the developed technologies. The initiative will be opened to people wishing to found tech start-ups in all fields, facilitating in this way the transition from basic research to industry will be facilitated.

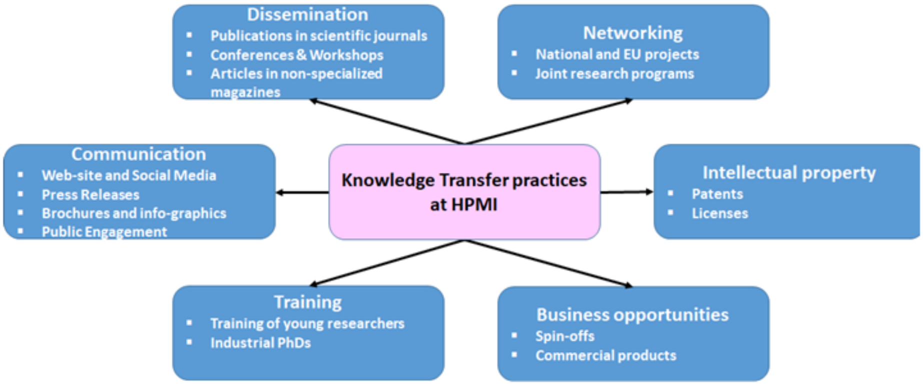

Fig. 14: Schematic representation of the main "knowledge transfer" practices at HPMI.

Finally, in the context of the Knowledge transfer promotion, one the main objectives of CNR is the formation of young people through research. In this context, CNR is the largest research Institution involved in the PhD programs of the Italian Universities with a significant investment of resources, and a well-defined own strategy of participation in the active doctoral courses. Within this strategy, in 2017 CNR signed an Agreement with Confindustria, the main association representing manufacturing and service companies in Italy, for the co-funding of **industrial PhD programs** on different topics, which are relevant for the innovation of the country. These programs are co-funded from CNR (50%) and the involved companies (50%). These industrial PhD programs have has ultimate goal the support of the country development through the *creation of new IP* and *transfer of knowledge*. In this framework, since 2018 CNR has activated already several joint PhD programs with large companies and SMEs operating in the territory (ST, LPE, Enel Green Power, ENI). As an example, only in 2022 4 PhD fellowships will be activated between IMM in Catania and ST and LPE in the field of new wide band semiconductors beyond silicon, which are addressed by the HPMI. Hence, in the next years this strategy, strongly encouraged by the *Department of Physical Sciences and Matter Technology* (DSFTM) of CNR, will be specifically addressed also to support the activities of HPMI. In the selection of the candidates for PhD programs at HPMI, particular attention will be put to on the **gender equality**, *by reserving at least 40% of the position to women*. To attract young talents, HPMI plans to periodically organize international **training courses** (either in presence or remotely) in materials science and device processing, targeting academic staff, Master and PhD students from University and research centers.

Part C – Expected impact

C.1. **Expected outcomes of the intervention**

The activities targeted mostly focus on the development of innovative technologies based on advanced materials (e.g., WBG, UWBG, 2D materials,…). They are KETs for the fabrication of power- and high-frequency devices with superior performances with respect to the existing silicon counterparts, in terms of efficiency, compactness, frequency and temperature operation, etc. These technologies will have a large economic impact and bright perspectives in the next years. In particular, the technological outcomes of HPMI will significantly contribute to the “know-how” development exploitable in several domains, e.g., *consumer electronics, automotive, renewable energies, industry, telecommunication, transportation,* etc. Specifically, the global power electronics market size is expected to reach $46.81 billion by 2027, rising at a market growth of 4.4% CAGR during the forecast period (Source: KBV Research). In such a market, wide band gap power semiconductors (today only the mature SiC and GaN), valued at $ 700 million in 2020, is expected to witness over 30% CAGR between 2021 to 2027 (source: Global Market Insight), with the following **share by application**.

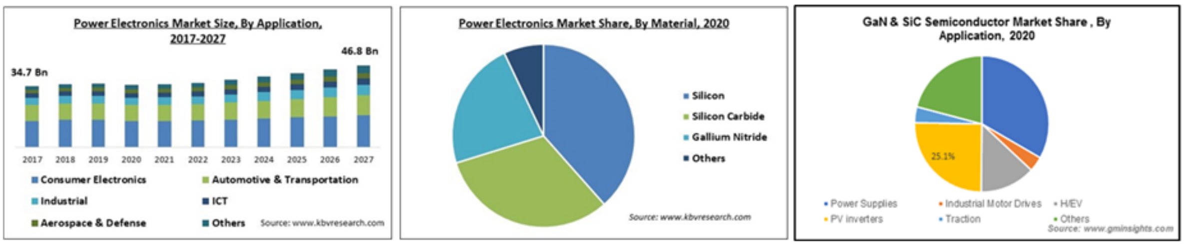

Fig. 15: Global power electronics market size by application (a) and by material (b) (Source: KBV research 2020). (c) Global market share of SiC and GaN by applications (Source: Global Market Insights 2020).

In this context, HPMI **will have an impact in increasing the IP development** on these strategic sectors for the economy, with a contribution estimable in the order of 10 patents/year.
The creation of HPMI will bring also great benefit for the overall **competitiveness of semiconductor industry**, pushing towards added-values technologies, reducing the gap with the other European countries and in general with respect to Asia competitors (by limiting the delocalization of jobs and technological development in those countries). From the public research point of view, the creation in Italy of such a *new model of infrastructure*, based on a strong public-private interaction, will provide a novel ecosystem for the **formation of a new generation of researchers** with expertise and skills on high-added-value technologies, and ready to enter in the productive world. This will be possible owing to the formation of *researchers specifically enrolled within funded projects*, and the intensive transfer of knowledge based on **training activities** (PhD fellowships, training courses, etc.). This virtuous cycle is expected to contribute to the creation of 20 job positions/year (considering the gender equality policy (see section B5), 40% of these jobs will be for women).
In terms of technological transfer, the HPMI will make treasure and improve the specific features of the “Etna Valley”, already mentioned in sections A2 and B1. In particular, this new public–private organization of HPMI will further facilitate the **sharing of resources and skills** and the development of **“a place with common language”** between people working in public research and industrial R&D. All these factors will be key issues to favour the process bringing the activities **from basic research to innovation at high TRL.**
While HPMI will operate mainly in the domain of semiconductor devices for beyond-silicon power- and high-frequency electronics, **other research or productive domains** will be interested by the activities of the infrastructure. In fact, the technological platform developed within HPMI can be also used for creating new devices for *optoelectronics, photonics and sensing*, and can have even future perspectives in *quantum technologies*. Hence, besides the large and medium high-tech companies (e.g STMicroelectronics, Leonardo, LPE, etc.), a variety of other **possible private end-users** of the developed “know-how” in several domains has been already identified, as described in section A8. Among them, also **equipment providers** will be strongly interested in improving their machines and create new products on the basis of the novel inputs coming from the research of HPMI.
Finally, another outcome will be related to the **Communication and Dissemination** activities, which will result in a significant scientific/technical production in specialized journals and magazines.
In summary, after the first 5 years of the creation of HPMI, the following outcomes are targeted in terms of scientific production, patents, Industrial PhDs and training events, etc.

Main expected HPMI's Outcomes		Number / year
Communication & Dissemination	*Scientific Publications*	50
	Conferences Participation	10
Intellectual property	*Patents*	10
Training	*Industrial PhD Students*	10
	Training courses	5
Funding	*Projects, contracts*	10
Jobs	*Employees*	20
Business	*Spin-offs, Technology transfers*	1 every 4 years

C.2. Long-term sustainability profile

HPMI will operate in the **semiconductors field**, whose market is projected to be $1193.4 billion in 2030 compared to $439.8 billion in 2020, with a CAGR of 9.90%. This indicates the strategic positioning of the infrastructure in key segments such as consumer electronics, automotive, wireless communications etc.

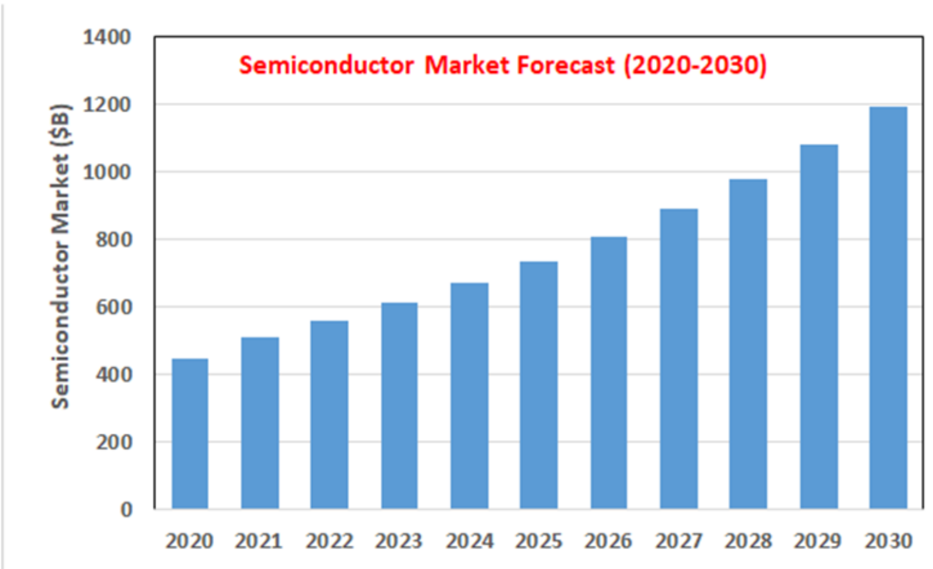

Fig. 15: Worldwide semiconductor market forecast growth in the current decade. Sales in 2022 are forecast to grow 11% after worldwide revenues climbed in the economic rebound form 2020 outbreak of the Covid–19 virus crisis. (Source International Business Strategies (IBS) - September 2021).

In these strategic and competitive segments, a robust long-term vision is essential to successfully develop and operate the infrastructure. Hence a **long-term sustainability plan** for the next 20 years has been already set up, to remain at the forefront of science and technology and to stay competitive in the field of micro- and nano-electronics.

This plan has been inspired to some recommendations from the *EU Commission Staff Working Document* on the long-term sustainability of research infrastructures, such as:

- Establish and maintain excellence (e.g., guarantee the access to the best research projects/users).

- Ensure to have the right people in the right place at the right time (i.e., by an adequate employment policy of excellent personnel, according to the commitments).
- Harmonize a vision for convergent operation of research infrastructures (e.g., by operating in synergy with other initiatives, as specified in A7).
- Fully exploit the potential as innovation hub (i.e., by the localization in the microelectronics hub of Catania).
- Set-up effective means for determining the economic and wider social value of HPMI (e.g., broaden the stakeholders' engagement, reinforce the integration in the regional/national scientific, social and economic ecosystems, etc.)
- Establish conditions for effective governance and sustainable long-term funding, fostering a broader coordination at National and European levels (e.g., by starting from the solid existing collaborative network of CNR).

The analysis of *infrastructure costs* has been carried out considering: (i) energy/utilities; (ii) routine maintenance; (iii) periodic equipment renewal; (iv) technical personnel costs; (v) management costs of the PPP.
Energy and utilities (special gases, consumables, etc.) were calculated based on a microelectronics facility of about 1000 m^2 and operating in class–10. They are expected to grow to a saturation level of about 1M€ per year as the facility will enter its full regime. At that stage, the routine maintenance will amount 1.85M€ corresponding to about 6% the total equipment investment. Besides the infrastructure manager, the technical personnel are differentiated into full-term positions for daily facility operation and temporary positions employed on projects. The cost of technical personnel, estimated considering the average annual cost of the different professional figures (i.e., infrastructure manager, process/device engineers and technologist), will approach a value of about 2M€ after 8 years. The management costs are related to legal and administrative consulting, administrative staff, Board of Directors, etc. The total operative expenditure will range from about 2.7 to about 9M€ per year (depending on the impact of the equipment renewal and of the activity related to contracts/projects).

The *income of the infrastructure* will be generated by the restricted access projects, National and European projects, Industrial contracts, services to the scientific community, and will gradually increase until reaching about 10.6M€ after ten years. Both open access (reserved to external users) and restricted access (reserved to the public and private institutions adhering to the PPP) have been considered, with the restricted access quota not exceeding 20% of the total HPMI capability.

It should be emphasized that 60% of the total income, at the full operation regime, will be focused on the interaction with Industrial stakeholders, through contract and/or orders.

		Energy/Utilities	Maintenance	Equipment renewal	Personnel costs (full-term positions for day-to-day facility operations)									Personnel costs (temporary positions on projects)							Total personnel costs	Special Purpose Vehicle (SPV) managment costs	Total OPEX
Year	t				Facility Manager		Process Engineer		Device Engineer		Technol.		Sub-Tot	Process Engineer		Device Engineer		Technol.		Sub-Tot			
2026	1	0.400	0.200		1	0.120	1	0.080	1	0.080	2	0.140	0.420	2	0.160	2	0.160	3	0.210	0.530	0.950	1.100	2.650
2027	2	0.450	0.400		1	0.120	1	0.080	1	0.080	2	0.140	0.420	2	0.160	2	0.160	3	0.210	0.530	0.950	1.100	2.900
2028	3	0.500	0.900		1	0.120	1	0.080	1	0.080	2	0.140	0.420	2	0.160	2	0.160	3	0.210	0.530	0.950	1.000	3.350
2029	4	0.600	1.400	1.050	1	0.120	2	0.160	2	0.160	3	0.210	0.650	2	0.160	2	0.160	4	0.280	0.600	1.250	0.900	5.200
2030	5	0.700	1.700	1.950	1	0.120	2	0.160	2	0.160	3	0.210	0.650	3	0.240	3	0.240	4	0.280	0.760	1.410	0.850	6.610
2031	6	0.830	1.820	2.800	1	0.120	2	0.160	2	0.160	3	0.210	0.650	4	0.320	3	0.240	5	0.350	0.910	1.560	0.850	7.860
2032	7	0.910	1.850	3.130	1	0.120	2	0.160	2	0.160	4	0.280	0.720	4	0.320	4	0.320	5	0.350	0.990	1.710	0.850	8.450
2033	8	0.960	1.850	2.800	1	0.120	2	0.160	2	0.160	4	0.280	0.720	4	0.320	4	0.320	7	0.490	1.130	1.850	0.850	8.310
2034	9	1.000	1.850	2.000	1	0.120	2	0.160	2	0.160	4	0.280	0.720	4	0.320	5	0.400	8	0.560	1.280	2.000	0.850	7.700
2035	10	1.000	1.850	1.200	1	0.120	2	0.160	2	0.160	4	0.280	0.720	5	0.400	5	0.400	8	0.560	1.360	2.080	0.850	6.980
2036	11	1.000	1.850	0.880	1	0.120	2	0.160	2	0.160	4	0.280	0.720	5	0.400	5	0.400	8	0.560	1.360	2.080	0.850	6.660
2037	12	1.000	1.850	1.200	1	0.120	2	0.160	2	0.160	4	0.280	0.720	5	0.400	5	0.400	8	0.560	1.360	2.080	0.850	6.980
2038	13	1.000	1.850	2.000	1	0.120	2	0.160	2	0.160	4	0.280	0.720	5	0.400	5	0.400	8	0.560	1.360	2.080	0.850	7.780
2039	14	1.000	1.850	2.850	1	0.120	2	0.160	2	0.160	4	0.280	0.720	5	0.400	5	0.400	8	0.560	1.360	2.080	0.850	8.630
2040	15	1.000	1.850	3.200	1	0.120	2	0.160	2	0.160	4	0.280	0.720	5	0.400	5	0.400	8	0.560	1.360	2.080	0.850	8.980
2041	16	1.000	1.850	2.850	1	0.120	2	0.160	2	0.160	4	0.280	0.720	5	0.400	5	0.400	8	0.560	1.360	2.080	0.850	8.630
2042	17	1.000	1.850	1.950	1	0.120	2	0.160	2	0.160	4	0.280	0.720	5	0.400	5	0.400	8	0.560	1.360	2.080	0.850	7.730
2043	18	1.000	1.850	1.040	1	0.120	2	0.160	2	0.160	4	0.280	0.720	5	0.400	5	0.400	8	0.560	1.360	2.080	0.850	6.820
2044	19	1.000	1.850	0.450	1	0.120	2	0.160	2	0.160	4	0.280	0.720	5	0.400	5	0.400	8	0.560	1.360	2.080	0.850	6.230
2045	20	1.000	1.850	0.200	1	0.120	2	0.160	2	0.160	4	0.280	0.720	5	0.400	5	0.400	8	0.560	1.360	2.080	0.850	5.980

Fig. 16 Operative costs of HPMI as a function of the time. The Special Purpose Vehicle (SPV) generally indicates the society formed by the public-private-partnership.

Year	t	Income					Income-OPEX			
		Protected access	Open access (National / European projects)	Open access (Industrial contracts)	Open access (services to the scientific community)	Total income	Income-OPEX	Income – Opex: Cumulative	% Protected Access	% Open access
2026	1	0.670	0.810	1.340	0.540	3.360	0.710	0.710	0.199	0.801
2027	2	0.760	0.900	1.540	0.600	3.800	0.900	1.610	0.200	0.800
2028	3	0.960	1.160	1.940	0.770	4.830	1.480	3.090	0.199	0.801
2029	4	1.370	1.660	2.830	1.060	6.920	1.720	4.810	0.198	0.802
2030	5	1.690	2.040	3.400	1.340	8.470	1.860	6.670	0.200	0.800
2031	6	1.860	2.240	3.750	1.480	9.330	1.470	8.140	0.199	0.801
2032	7	1.990	2.400	3.980	1.570	9.940	1.490	9.630	0.200	0.800
2033	8	2.040	2.480	4.110	1.640	10.270	1.960	11.590	0.199	0.801
2034	9	2.080	2.520	4.180	1.690	10.470	2.770	14.360	0.199	0.801
2035	10	2.100	2.550	4.210	1.690	10.550	3.570	17.930	0.199	0.801
2036	11	2.120	2.550	4.260	1.690	10.620	3.960	21.890	0.200	0.800
2037	12	2.120	2.550	4.260	1.690	10.620	3.640	25.530	0.200	0.800
2038	13	2.120	2.550	4.260	1.690	10.620	2.840	28.370	0.200	0.800
2039	14	2.120	2.550	4.260	1.690	10.620	1.990	30.360	0.200	0.800
2040	15	2.120	2.550	4.260	1.690	10.620	1.640	32.000	0.200	0.800
2041	16	2.120	2.550	4.260	1.690	10.620	1.990	33.990	0.200	0.800
2042	17	2.120	2.550	4.260	1.690	10.620	2.890	36.880	0.200	0.800
2043	18	2.120	2.550	4.260	1.690	10.620	3.800	40.680	0.200	0.800
2044	19	2.120	2.550	4.260	1.690	10.620	4.390	45.070	0.200	0.800
2045	20	2.120	2.550	4.260	1.690	10.620	4.640	49.710	0.200	0.800

Fig. 17 Income of the HPMI infrastructure. The restricted access (indicated as protected) is essentially based on contracts stipulated with partners of the PPP, whilst open access will consist of project funded by National or European Public Institutions, technological activity committed and funded by Industry, and services required by the scientific community.

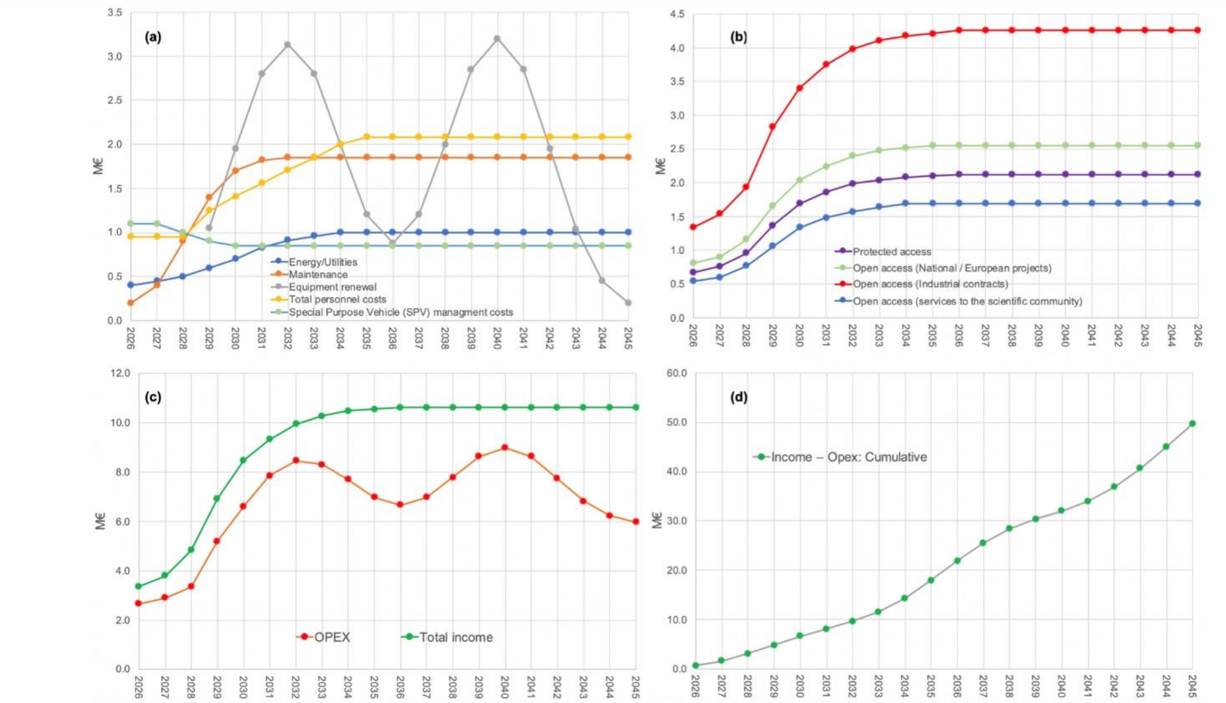

Fig. 18 Plots of the essential figures representing the sustainability plan of HPMI infrastructure. (a) Details of the operative costs. (b) Profiles of the different income items. (c) Total costs and total income. (d) Cumulative difference between total income and total operative costs. The budget of HPMI infrastructure maintains positive through all the examined time range.

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To:
National Research Council of Italy (CNR)
Department of Physical Science and Matter Technology (DSFTM)
- *Attention of: Mr. Rosario Corrado Spinella* -

Object: Expression of interest for the initiative "High Performance Microelectronics Infrastructure" (HPMI), within the PNRR Call n. 3265, 28.12.2001 - "Avviso per la Concessione di Finanziamenti Destinati alla Realizzazione o Ammodernamento di Infrastrutture Tecnologiche di Innovazione".

This letter is to acknowledge that STMicroelectronics S.r.l., a company with recognized skills and resources in the field of micro and nano-electronics technologies, expresses its interest for the initiative "High Performance Microelectronics Infrastructure" (HPMI) and for Research & Development activities envisaged within the HPMI.

STMicroelectronics S.r.l. is interested to pursue the above-mentioned initiative in the form that will be deemed more suitable for the project according to a business model that will be agreed at a later stage.

STMicroelectronics S.r.l. is considering the possibility to grant the use of the spaces and/or to provide any other support activities necessary to carry out the activities of HPMI. It is understood that the above is not meant to be a legal binding commitment for STMicroelectronics S.r.l.

In this regard, we agree to handle with convenient confidentiality all the information and documents on the initiative received to date.

Best Regards,

Agrate Brianza, March 9th, 2022

STMicroelectronics S.r.l.
Orio Bellezza
Managing Director

Finanziato dall'Unione europea
NextGenerationEU

MUR

Powering the future

Epitaxial Technology

To:
Dott. Rosario Corrado Spinella
National Research Council of Italy (CNR)
Department of Physical Science
and Matter Technology (DSFTM)

Object: Expression of interest for the initiative "*High Performance Microelectronics Infrastructure*" *(HPMI)*, within the PNRR Call n. 3265, 28.12.2001 - "Avviso per la Concessione di Finanziamenti Destinati alla Realizzazione o Ammodernamento di Infrastrutture Tecnologiche di Innovazione".

Herewith, the company LPE spa, with registered office in Via Falzarego 8, 20021, Baranzate (MI) and secondary branch in 16a strada, Zona Industriale Pantano d'Arci, 95121, Catania (CT), with reference to the aforementioned **"High Performance Microelectronics Infrastructure" (HPMI),**

Owing to its recognized skills and resources in the field of Epitaxial Reactors and Process R&D and commercialization and Wide Band Gap (WBG) materials Research & Development, which can be relevant for the achievement of the objectives targeted by HPMI,

Expresses

- Its interest in the realization of such an infrastructure and in the capability of developing the excellence in Research & Innovation within the HPMI.
- Its interest in supporting the initiative either as an external user or in the form of a cooperation within future joint projects or through the direct participation in the public-private-partnership for the implementation of HPMI, in a way that will be later defined and ruled in a written form by dedicated agreements.

In this regard, we agree to handle with convenient confidentiality all the information and documents on the initiative received to date.

Best Regards,

Baranzate, 07 of March 2022

LPE Spa

Massimo Sordi – Chairman of the Board

MERIDIONALE IMPIANTI

Meridionale Impianti S.p.A
Capitale Sociale EURO 30.000.000 i.v.
Cod. Fisc. / P.IVA: 00853070878
Rea: Monza Brianza-1867560

Sede Legale -Direzione Generale
Via Senatore Simonetta 26/D
20867 Caponago (MB)
Pec. meridionaleimpianti@pec.merimp.com

To:
Dott. Rosario Corrado Spinella
National Research Council of Italy (CNR)
Department of Physical Science
and Matter Technology (DSFTM)

Object: Expression of interest for the initiative "*High Performance Microelectronics Infrastructure*" *(HPMI)*, within the PNRR Call n. 3265, 28.12.2001 - "Avviso per la Concessione di Finanziamenti Destinati alla Realizzazione o Ammodernamento di Infrastrutture Tecnologiche di Innovazione".

Herewith, the company *Meridionale Impianti* with registered office in *Via Senatore Simonetta 26/D , 20867, Caponago (MB)* and secondary branch *in Bivio Aspro Zona Industriale di Piano Tavola , 95032, Belpasso, Catania*, with reference to the aforementioned **"High Performance Microelectronics Infrastructure" (HPMI),**

Owing to its recognized skills and resources in the field of Ultra High Purity facitilies for Semiconductor which can be relevant for the achievement of the objectives targeted by HPMI,

Expresses

- Its interest in the realization of such an infrastructure and in the capability of developing the excellence in Research & Innovation within the HPMI.
- Its interest in supporting the initiative either as an external user or in the form of a cooperation within future joint projects or through the direct participation in the public-private-partnership for the implementation of HPMI, in a way that will be later defined and ruled in a written form by dedicated agreements.
- Its interest in the Knowledge transfer and Business Creation activities such as the creation of start ups

In this regard, we agree to handle with convenient confidentiality all the information and documents on the initiative received to date.

Best Regards,

Catania , 04 March 2022

COMPANY NAME
(Giovanni Raffa , CEO)
Signature

MERIDIONALE IMPIANTI S.p.A.
Sede leg. Via Senatore Simonetta 26/D
20867 CAPONAGO (MB)
Uff. Amm.vo: Bivio Aspro - Z.I. Piano Tavola
95032 Belpasso (CT)
Partita IVA 00853070878

Finanziato dall'Unione europea
NextGenerationEU

MUR

Sant'Anna
Scuola Universitaria Superiore Pisa

LA RETTRICE

To Rosario Corrado Spinella
Department of Physical Science and Technology of Matter
National Research Council of Italy

Dear Dr. Spinella,

Italy needs to strengthen its Innovation Infrastructures, spread an entrepreneurial culture, promote innovation, via patenting, licensing, creation and development of start-ups, with contribution of venture capital and private investments. Integrating emerging technologies into production is essential to strengthen the competitiveness of Italian companies and increase employment opportunities. These new technologies comprise quantum-based computation, simulations, communications and sensors, composites, new layered materials and devices for 5G/6G and beyond. Knowledge-based innovation is mandatory to address major social challenges identified by the UN Sustainable Development Goals, with an impact on health, food, water, climate change, migratory trends, digital transition.

Scuola Superiore Sant'Anna (SSSA) hopes to establish an Innovation Infrastructure on Quantum, advanced Materials and Photonics (QMPI) to stimulate the development of innovative technologies in cooperation with industry. QMPI will exploit the new possibilities that quantum science and advanced materials create in the ways we process, distribute and sense information, and for the development of new devices for the energy transition

We are pleased to see your proposal for a "High Performance Microelectronics Infrastructure" (HPMI) in the microelectronics hub of Catania, aiming at developing key enabling technologies on advanced materials for next generation of micro– nanoelectronics devices. These can be useful for several application fields, e.g., automotive, consumer electronics, sustainable energy, efficient power management, aerospace, robotics, merging multiple competences coming from the Si world and going beyond it.

I believe our proposed Innovation Infrastructures to be fully complementary. They target areas of strategic National and EU interest, focussing on photonics (Pisa), and electronics (Catania). We will greatly benefit from a close collaboration and alignment of strategic targets. Together we will serve the need of Italian Industries (from SMEs to large corporations), as well as Universities and research centres.

I note that both HPMI and QMPI respond to the call for strategic infrastructures of the EU Chips Act. This requires both EC and Member States to establish advanced pilot lines to test, validate and develop next generation devices and products.

I believe CNR and SSSA can forge ahead with a strong collaboration for the benefit of the entire country, with our proposed infrastructures being the seed for technological diversification and key enablers for the transition of the excellent new ideas developed in Italian Universities and research centres to their implementation into products, with economic and societal benefits.

I wish you the best of luck with your application.

Yours Sincerely,

Prof. Sabina Nuti
Rector of Scuola Sant'Anna

Firmato digitalmente da: NUTI SABINA
Data: 09/03/2022 15:53:08

Finanziato dall'Unione europea
NextGenerationEU

MUR
Ministero dell'Università e della Ricerca

INTESA SANPAOLO

To:
Dott. Rosario Corrado Spinella
National Research Council of Italy (CNR)
Department of Physical Science
and Matter Technology (DSFTM)

Milan, 7th March 2022

Object: Letter of support for the initiative "*High Performance Microelectronics Infrastructure*" *(HPMI)*, within the PNRR Call n. 3265, 28.12.2001 - "Avviso per la Concessione di Finanziamenti Destinati alla Realizzazione o Ammodernamento di Infrastrutture Tecnologiche di Innovazione".

To whom it may concern,

with reference to the aforementioned "High Performance Microelectronics Infrastructure" (HPMI), **We INTESA SANPAOLO**, *a leading Bank in Italy, with a strong experience in the field of R&D&I financing, specialized in supporting investments in Research & Innovation and in offering Corporate Finance services to support enterprises in their business development and innovation process,*

hereby express

- our interest in the realization of such an infrastructure and in the capability of developing the excellence in Research & Innovation within the HPMI.
- our interest in supporting the initiative as lender and/or financing advisor for the structuring of a public-private-partnership for the implementation of HPMI, that will be later defined and ruled in a written form by dedicated agreements.

In this regard, we agree to handle with convenient confidentiality all the information and documents on the initiative received to date.
This letter of interest does not entail a formal engagement at this point and doesn't contain any binding commitment on the prosecution and subsequent conclusion of the negotiations which could eventually be released only after an assessment of the development of the project. However, Intesa Sanpaolo wishes to declare its interest in the project.

Best Regards,

Riccardo Domenico Dutto
Global Head of Infrastructure and Real Estate

INTESA SANPAOLO

The Intesa Sanpaolo Group is one of the top banking groups in Europe, with a market capitalisation of 44.2 billion euros as at 30 December 2021, and is committed to supporting the economy in the countries in which it operates, specifically in Italy where it is also committed to becoming a reference model in terms of sustainability and social and cultural responsibility.
Intesa Sanpaolo is the leader in Italy in all business areas (retail, corporate, and wealth management). The Group offers its services to 13.5 million customers through a network of approximately 4,200 branches well distributed throughout the country with market shares no lower than 12% in most Italian regions.
Intesa Sanpaolo has a strategic international presence, with approximately 1,000 branches and 7.1 million customers, comprising subsidiaries operating in commercial banking in 12 countries in Central Eastern Europe and Middle Eastern and North African areas and an international network of specialists in support of corporate customers across 26 countries, in particular in the Middle East and North Africa and in those areas where Italian companies are most active, such as the United States, Brazil, Russia, India and China.

Finanziato dall'Unione europea
NextGenerationEU

MUR
Ministero dell'Università e della Ricerca

Meridiam
for people and the planet

Private and confidential

To:
National Research Council (CNR) of Italy
Department of Physical Science and Technology of Matter
Piazzale A. Moro, 7
00185 Roma, Italy

Paris, 08 March 2022

Dear Sirs,

High Performance Microelectronics Infrastructure (HPMI)

Expression of Interest

We refer to the proposal being submitted by You related to the development of a High-Performance Microelectronics Infrastructure (HPMI) to be developed in the microelectronics hub of Catania (the "**Proposal**"), in the context of the call for proposals no. 3265 published on 28 December 2021 by the Ministry of University and Research (MUR) of the Republic of Italy concerning the granting of finance for the realization or renovation of technological infrastructure.

Meridiam was founded in 2005 by Thierry Déau, with the belief that the alignment of interests between the public and private sector can provide critical solutions to the collective needs of communities. Meridiam is an independent investment Benefit Corporation under French law and an asset manager. The firm specializes in the development, financing, and long-term management of sustainable public infrastructure in three core sectors: sustainable mobility, critical public services, and innovative low carbon solutions. With offices in Addis Ababa, Amman, Dakar, Istanbul, New York, Luxembourg, Paris, Toronto, Vienna, Libreville, and Johannesburg, Meridiam currently manages US$18 billion and more than 100 projects to date. Meridiam is certified ISO 9001: 2015, Advanced Sustainability

Rating by VigeoEiris (Moody's) and applies a proprietary methodology in relation to ESG and impact based on United Nations' Sustainable Development Goals (SDGs).

We hereby confirm our interest in principle to participate in the future call for tender that could be launched in relation to the design, construction, financing, operation, and maintenance the High-Performance Microelectronics Infrastructure (HPMI) described in the Proposal.

This letter is not purported to and shall not constitute (nor can be for whatever reason interpreted as) any commitment or offer from Meridiam S.A.S. and/or other entities of the same group.

This letter (and the existence and contents hereof) shall be confidential and may not be disclosed (in whole or in part) to any person without our prior written consent.

This letter is submitted by Meridiam S.A.S., in its role as manager for and on behalf of one of the managed funds.

This letter is governed by (and shall be construed and interpreted in accordance with) the laws of the Republic of Italy. Any dispute arising out of or in connection with this letter (including any non-contractual obligations arising out of or in connection with it) shall be submitted to the exclusive jurisdiction of the courts of Milan.

We look forward to hearing from you soon.

Yours faithfully,

Name: Marco Rosso

Title: Partner, Global Business Development Director

For and on behalf of: Meridiam S.A.S.