Program Scheme

Activation within the PhD course in **PHYSICS** of the following Research Program, based on the resources referred to Ministerial Decree no. 351/2022, related to the following Measure:

[X] **M4C1- Inv. 4.1** *"Estensione del numero di dottorati di ricerca e dottorati innovativi per la pubblica amministrazione e il patrimonio culturale".* In particolar:

[X] **Dottorati PNRR**

❖ **Research Program Title**: Plasmonic resonances in silicon nanostructures

❖ **Descrizione** (MAX 5000 CARATTERI SPAZI ESCLUSI)**:**

Objectives:
A resonant cavity induced by plasmons in silicon nanostructures is scientifically and technologically very interesting because it finds various applications in several fields, including the innovative one of efficient photoconversion. The very recent development of silicon nanostructure solar cells that show higher efficiency than traditional cells, and the possibility of industrial integration offered by silicon, make the perspective much more actual than other approaches. However, fabricating small silicon nanostructures and studying their plasmonic behavior is a non-trivial challenge. For this reason, the findings in the literature on these plasmonic phenomena in silicon, and specifically in silicon nanostructures, are very few and the understanding is quite preliminary. The doctoral thesis will aim to optimize the growth methods and characterize the plasmonic behavior of these nanostructures. Plasmonic resonances will also be investigated in terms of of longitudinal and transverse oscillations, both propagating and localized. Alongside these innovations, the student will be able to investigate the phenomenon by carrying out simulations on plasmonic behavior at the foreign university and will tackle the development of appropriate software applications for data analysis at the host company.
Main innovations:
1) investigation of plasmonic phenomena with high energy and spatial resolution, thanks to the use of instrumentation unique in Italy; 2) theoretical study of resonances thanks to the collaboration with international groups, expert in this sector; 3) application to advanced solar cells with high efficiency of photoconversion thanks to the possibility of using clean rooms equipped with state-of-the-art equipments.
Coherence of the proposed program with the chosen Measure:
The project is consistent with the "COMPONENT 2 (M2C2) Renewable energy, hydrogen, grid and sustainable mobility of MISSION 2 (M2) Green revolution and ecological transition" of the Italian PNRR and, through the development of more efficient and more competitive solar cells, is aimed at: 1) strengthening smart grid; 2) agro-voltaic development; 3) promotion of renewables for energy communities and self-consumption.
Impact of the research:
The program that will be developed as part of the PhD in Physics at UniME, CNR-IMM as collaborating partner of the project, Tirrito Elettronica and SDU, complies with the objectives set by the PNRR. The results will have an impact in terms of: a) improvement of environmental sustainability: definition of procedures for energy production; b) acceleration of digital transformation processes: through the development of software applications suitable for data analysis at the hosting company, and simulation of plasmonic phenomena in silicon nanostructures; c) promotion of social inclusion: development of strategies

that improve the performance of solar cells, and raising awareness of society towards the issue of ecological transition through the proposal of cheaper and more efficient devices.
Educational activity:
Participation in: 1) lectures scheduled for the PhD course in Physics; 2) international schools for PhD students; 3) exchange paths between the world of research and the company.
Research activity:
The student will acquire specific skills in the synthesis and characterization of nanomaterials with the most advanced techniques, at UniME and at the CNR-IMM as collaborating partner of the project, such as chemical vapor deposition (CVD), transmission microscopy (TEM) with high spatial resolution, combined with chemical (EDX) and spectroscopic (EELS) in-situ characterization techniques, aimed at the acquisition of plasmon resonance signals in nanomaterials; use of clean rooms for the manufacture of advanced solar cell prototypes; electric characterization benches for the measurement of photoconversion efficiency. He will also acquire skills on simulations of plasmonic behavior at the foreign university and will tackle the development of appropriate software applications for data analysis at the host company.
Communication and Dissemination Activities:
The activities will consist not only in the writing of scientific articles for journals with a high impact factor, and in the communication at international scientific conferences in the sector, but also in the dissemination to the general public through the institutional social communication channels (Linkedin , Facebook, Instagram) of the partners involved.

❖ **TIME TO BE SPENT AT ENTERPRSE– RESEARCH CENTERS – P.A..:**
The research program will be carried out in collaboration with the following subject:

Company name: Elettronica Tirrito srl
Registered office: Via San Leone 169, 94100 Enna
Legal representative: Tirrito Salvatore

The aforementioned institution will host the PhD student beneficiary of the scholarship financed on the resources of Ministerial Decree 351/2022 for no. 6 months (min 6 max 12) during the doctorate.

❖ **PERIOD ABROAD:**
The research program provides for a period abroad of No. 6 months (min 6 max 18) at the following institution:
SDU Centre for Photonics Engineering
University of Southern Denmark (SDU)
Campusvej 55, 5230 Odense-M, Denmark

We also declare that this program complies with the principle "not to cause significant damage" (DHSH) pursuant to art. 17 of regulation (EU) 2020/852 in coherence with the technical guidelines prepared by the European Commission (Communication of the European Commission 2021 / C58 / 01) and guarantees compliance with the horizontal principles of the PNRR (contribution to the climate and digital target so-called tagging, the principle of gender equality and the obligation to protect and enhance young people).