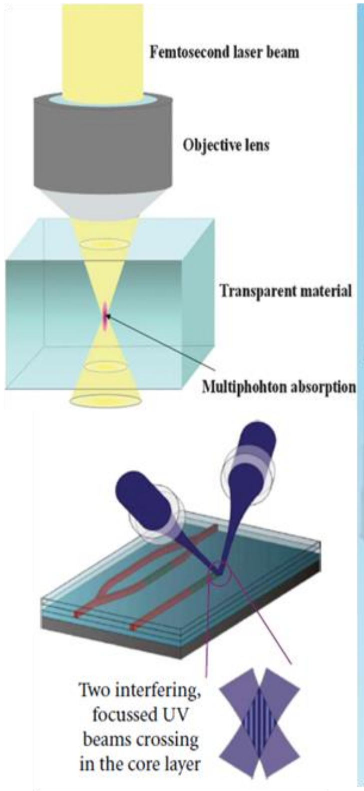
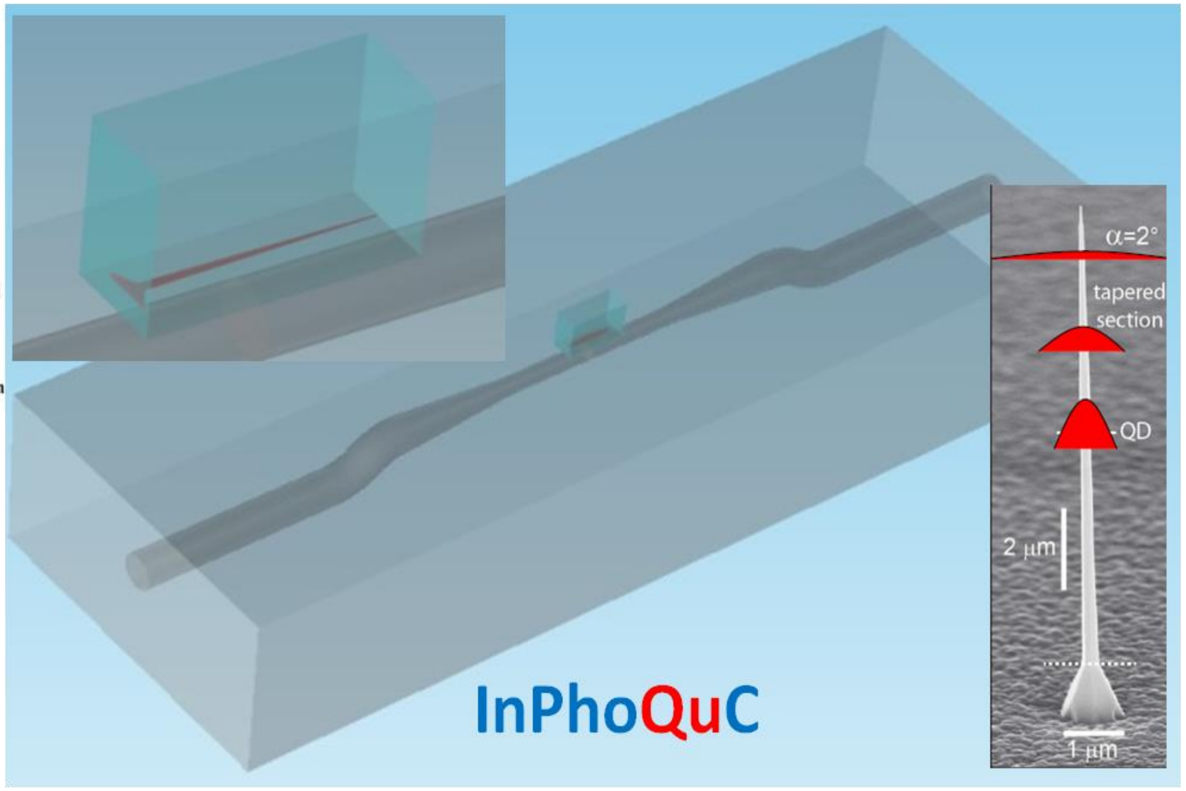
Hellenic Foundation for Research & Innovation

Description of the funded research project

1st Call for H.F.R.I. Research Projects to Support Faculty Members & Researchers and Procure High-Value Research Equipment

Title of the research project: Integrated Photonic Quantum Circuits





Principal Investigator: Dr. Christos Riziotis

Reader-friendly title: InPhoQuC

Scientific Area: Natural Sciences

Institution and Country:
National Hellenic Research Foundation, Greece

Host Institution:
National Hellenic Research Foundation, Greece

Collaborating Institution(s):
1)Optoelectronics Research Centre (ORC), University of Southampton, U.K.,
2) KTH Royal Institute of Technology, Sweden

Budget: 199.650,00 Euros

Duration: 36 Months

Research Project Synopsis

It has been proven theoretically that Quantum Computers can be implemented by combining and using classical optical gates and optical components, like, beam splitters, phase shifters, single photon sources and single photon detectors. Such Linear Optics Quantum Computers (LOQC) could be implemented by integrated photonics.

The scope of project InPhoQuC is the development of such quantum devices by the robust and highly controllable classical-in-nature integrated optical circuits based on Silica-on-Silicon material systems which is the major integration platform compatible for interconnection with conventional optical fibers' telecommunications infrastructure. InPhoQuC will employ flexible Laser direct writing and micro-machining technology by infrared femtosecond laser or CW Ultraviolet Lasers for the inscription of multifunctional waveguide structures and circuits.

The main targets of the project are:

1) The deterministic integration of semiconductor nanowire quantum dots (NQD) in silica channel waveguides for the development of on-chip single photon quantum emitters that will enable circuit's scalability by multiple emitters' integration. Suitable waveguide structures and adiabatic mode transformers for the efficient coupling of quantum emitters' photons in the circuitry will be designed and fabricated by direct Laser writing techniques.

2) Integration of NQDs will enable multiple wavelength photons on-chip allowing in turn Wavelength Division Multiplexing - WDM operations for increasing the entire quantum-bit rate. Such WDM and Optical Add Drop Multiplexers (OADM) based on waveguide coupler structures will be designed and fabricated for demonstration of multicolor photon filtering and multiplexing actions on-chip.

Project originality

Until today silica based optical circuits employ externally connected single photon sources based on nonlinear optical processes (parametric down conversion). Such processes are highly inefficient and probabilistic in nature limiting the photons visibility and performance. Most importantly this approach limits drastically the scalability of optical based quantum computers by not providing means of multiple single photon sources on chip.

The project targets to internationally demonstrate, for the first time, the deterministic integration of multiple single-photon sources in silica-on-silicon waveguide circuits, enabling thus in turn the demonstration of on-chip filtering and wavelength multiplexing operations of multi-wavelength single photons. The incorporation of different multiwavelength quantum emitters in silica channel waveguides will provide the means for a multi-qubit multiwavelength circuit of enhanced functionality and increased qubit rate

Expected results & Research Project Impact

The main expected results of the project InPhoQuC are:

a) The successful hybrid integration of efficient quantum emitters in silica waveguides on-chip.
b) The demonstration of multiwavelength photons processing on-chip by customized WDM components.

The outcome of the project is expected to have a significant impact on the scalability enhancement of quantum circuit's towards the successful implementation of expandable architectures of quantum computers and quantum information processing systems.

Quantum computers implementations can provide immense computing power that can have extraordinary implications in ICT, cryptography, bioinformatics, drugs design, medical diagnostics, large scale prognostic models, changing drastically the entire status of current technology worldwide.

The developed prototype is expected to be at a technological maturity level or TRL 3 to 4.

The importance of this funding

InPhoQuC is very demanding and challenging project bringing together experimental and theoretical expertise from Material Science, Photonics Engineering and Quantum Optics. InPhoQuC seeks to solve some difficult multidisciplinary issues implying certain potential dangers in its implementation. While its impact is clearly visible but not immediate in computing industry, ELIDEK provided the required funding to implement such an ambitious project in fundamental research, that otherwise would be difficult to get funded it the frame of classical technological and industrial collaborative funding schemes.

Funding from ELIDEK is crucial for enabling also the physical on-site collaboration with the partners ORC (University of Southampton, UK) and KTH (Sweden) amplifying drastically the potential of combined unique international expertise. As Principal Investigator, the successful implementation of the project and eventually the grant of new intellectual property will place my research group and the country at a competing international position of emerging and vibrant quantum computing industry.

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