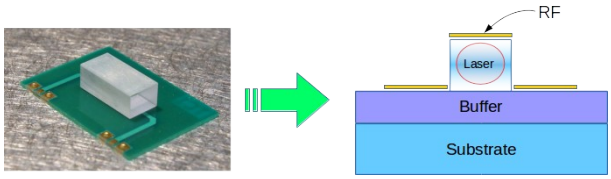
NÉEL INSTITUTE Grenoble

Topic for Master 2 internship – Academic year 2019-2020

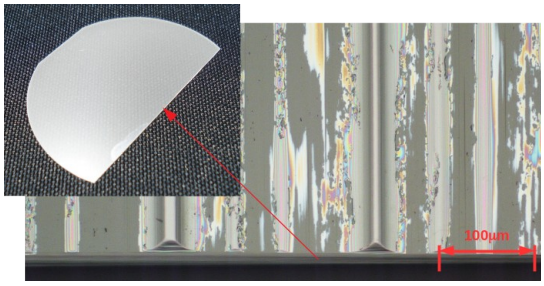
Guided interactions with rare-earth luminescent centers for quantum information processing

General Scope:

Rare-earth ions because of their unique 4f electronic configuration form well isolated systems when embedded in solids. They have long coherence time at low temperature making them highly promising qubits for the development of quantum technologies. Their well-known optical transitions can be now used as a support for optical quantum memories and more generally as a fast and versatile element of control on the qubit. High quality optical crystals containing rare-earth as low concentration impurities can be obtained routinely. The qubit manipulation using both optical and radio-frequency excitations is directly performed on millimeter-size bulk with a going through laser beam and proximity electrodes RF coupling (see figure). Higher integration is desired (see figure, left) not only to improve the readiness level of quantum technologies but also to obtain a stronger optical and RF coupling leading to a faster operation time.



Bulk oxides doped with rare-earth ions can be advantageously replaced by semiconductor doped matrices to shrink the device to micro-size scale and then benefiting from a strong optical and RF field confinements for qubit addressing.



GaN on sapphire template (left) grown at CEA. Zoom: Ridge waveguide fabricated by diamond saw dicing

Research topic and facilities available:

In this project, we propose to investigate experimentally a new platform for rare-earth based quantum processing by considering epitaxial semiconductors as host matrices instead of bulk oxides (see figure). The growth and fabrication of III-V semiconductors (see figure, right) inheriting from years of development in electronics allow to access micro- and nano-size samples. Bulk devices can now be compacted by three orders of magnitude allowing a stronger (optical and RF) fields confinement and a much faster qubit control as a consequence.

At the start of the project and depending on the expectation of the candidate, the internship can be oriented toward the sample fabrication and/or the design of the optical setup to probe thin epitaxial films. Both aspects are very demanding in terms of technical skills with material engineering on one side and optical design in low temperature environment on the other side.

Possible collaboration and networking: M. Hocevar (Néel), B. Daudin CEA/IRIG

Possible extension as a PhD: Yes

Required skills: Experimental including optics, materials science and engineering, nanofabrication.

Starting date: between January and April 2020

Contact:

Name: Thierry Chanelière Institut Néel - CNRS

Phone: 04 76 88 10 07 e-mail: thierry.chaneliere@neel.cnrs.fr

More information: http://neel.cnrs.fr