Polarimetric Raman instrumental development and Stress measurement application by using polarized Raman spectroscopy

Gerald Ndong, Julien Le Clec'h, Marc Chaingneau, Jean-Luc Hallaert, Mauro Bettati, Razvigor Ossikovski

a LPICM – Ecole Polytechnique, b HORIBA Jobin Yvon, c 3SPHOTONICS

Scientific and technical objectives

- CONTRAM: Determining the stress tensor through spatially resolved polarimetric Raman spectroscopy
- Polarmetric Raman spectrometer development (LPICM, HORIBA Jobin Yvon)
- Validation of the method by reference samples and techniques (LPICM, CEA-LETI)
- Applications in the stress characterization to innovative structures (LPICM, CEA-LETI)
- Applications in the stress characterization to semiconductor (Si, SiGe, Ge, GaAs...) and photonic structures (STM, 3SP, LPICM)

Stress measurement trough polarized Raman: from Si to SiGe and Ge

- Experimental setup: HORIBA - LPICM
  - Experimental methodology:
    - SiGe deposited on Si substrate
    - Samples and methodology of strain measurement
      - Spectrum acquisition as function incident polarization orientation
      - Determining of Raman shift
      - Adjustment the results with the numerical model for strain or stress tensor identification
    - Results

From polarized Raman to polarimetric Raman...

- Real polarimetric response of the system in Raman scattering
  - Confocal Raman configuration
  - Dop variation between 0.95 et 1
  - Three components \( S_1, S_2, S_3 \) constitute ellipse and no united circle
  - Presence of:
    - Depolarization
    - Dinitiation
    - Birefringence

3D PHOTONICS RESULTS (with University of McMaster)

- Samples:
  - High power laser diode AlGaAs/GaInAs
  - Lass braze in elastic alloy AaSn [80-20 wt%]
  - p-side up - assembly
  - Stress is due to the cooling of the assembly because of difference of thermal expansion coefficient and the dimensional disparities
  - Decreasing of the strain by bi-materials approach

  1. Theoretical approach: Modeling by finite element method (FEM)
  - 3D thermo-mechanics model
  - Mechanical properties of materials
  - Simulation of brazing solidification
  - Cooling from 280°C to 20°C
  - Determining of the Stress tensor

  2. Experimental approach: degree of polarization (DoP) measurement trough photoluminescence
  - Photoluminescence emitted by superior face of the plan diode AlGaAs/GaInAs
  - DoP is proportional to the difference of strain according to two axis of the studied plan
    - \( \Delta \sigma = \frac{\Delta \delta}{\sigma_{xx}} \times \tau - r \)

  Results:
  - FEM: Reducing the stress level to -20%
  - DoP: Reducing the stress level to -40%
  - Double side effect on bi-material submount

Results to be confirmed in polarized or polarimetric Raman by LPICM