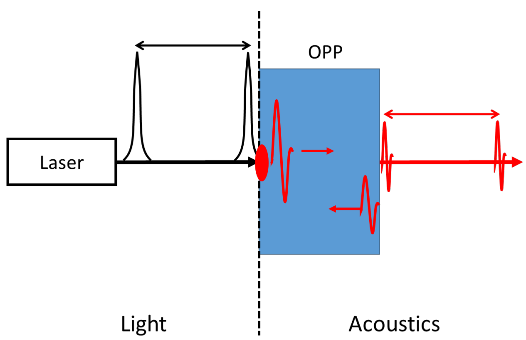
EMN_Sujet thèse / PhD subject 2024

Titre Thèse	Parametric Phononic Oscillator: Towards a phononic laser	
(Co)-Directeur	Arnaud DEVOS	E-mail : arnaud.devos@iemn.fr
(Co)-Directeur		E-mail :
(Co)-Encadrant (s)		E-mail :
Laboratoire	IEMN	Web : www.iemn.fr
Groupe(s)	Physique / Nanoacoustique	Web :
Projet phare (principal)	Nano-caractérisation	
Demande thèse labelisée IEMN (Materials ou IoT Make Sense)		**Non**
Financement demandé	Contrat Doctoral Etablissement	ULille ☒ Centrale Lille ☐ JUNIA ☐
	Région – Autre ☐ Préciser :	Co financement (Préciser l'origine, demande en cours, acquis ou pas) :
Financement acquis ☐ **Financement partiellement acquis** ☐	Contrats de Recherche ☐ Préciser :	Autre ☐ Préciser :

Résumé du sujet : Many applications take advantage of the non-invasive nature of acoustic waves to perform inspection and characterization in a totally non-destructive way. This is the case for medicine with echography, but also in the most advanced technologies of microelectronics, where complex stacks of thin films are inspected using ultra-high acoustic waves. Below 1GHz, acoustic waves are emitted and detected using transducers made of piezo-electric materials. To characterize a smaller object, one needs higher frequency. Thirty year ago, H. Maris discovered that ultra-short optical pulses can excite much higher acoustic waves, typically a few 100 GHz. Since then, we have learned to perform acoustic characterization at the nanoscale using a femtosecond laser - the *picosecond acoustic* field.
What's still missing is a powerful acoustic source in this hypersonic range (i.e. above 1 GHz). We propose here to develop a new acoustic source combining ultra-high frequency and power, referred to in the following as PPO for Parametric Phononic Oscillator. The main idea has been patented*, but a concrete demonstration remains to be done.
Basically, the PPO is based on an acoustic cavity (made by technology) which is pumped by a femtosecond laser. Each light pulse is first converted into an acoustic pulse in the cavity. When the repetition rate of the laser is adjusted to the PPO cavity, we predicted that some acoustic gain is expected. This way, the laser light is converted into a phonon laser. Thanks to this new source, new applications in non-destructive characterization are expected, for example wafer bonding in 3D microelectronics.



The work comprises several parts: technology for preparing the PPO cavity ; ultrafast optics to test the PPO device; numerical modeling of the acousto-optic signal to optimize the PPO gain.

* A. Devos, « Oscillateur Paramétrique Phononique", brevet mondial WO 2019/154967 A1