TRANSITION FROM STRONG COUPLING TO EXCITONIC LASING IN A ZNO MICROCAVITY

LABORATOIRE CHARLES COULOMB MONTPELLIER

C. Brimont[1,2], T. Guillet[1,2], M. Mexis[1,2], T. Bretagnon[1,2], B. Gil[1,2], P. Valvin[1,2],
F. Médard[3], M. Mihailovic[3], J. Zúñiga-Pérez[4], M. Leroux[4], F. Semond[4], S. Bouchoule[5]

[1] Université Montpellier 2, Laboratoire Charles Coulomb UMR 5221, F-34095, Montpellier, France
[2] CNRS, Laboratoire Charles Coulomb UMR 5221, F-34095, Montpellier, France
[3] LASMEA, UMR 6602, UBP – CNRS, 24 Avenue des Landais, F-63177 Aubière, France
[4] CRHEA – CNRS, Rue Bernard Grégory, F-06560 Valbonne, France.
[5] LPN – CNRS, Route de Nozay, F-91460 Marcoussis, France.

The lasing operation of a ZnO planar microcavity under optical pumping is demonstrated from T=80 to 300 K. At the laser threshold, the cavity switches from the strong coupling to the weak coupling regime.
A gain-related transition, which appears while still observing polariton branches and, thus, with stable excitons, is observed below 240 K. This mechanism is different from the standard VCSEL operation, which only relies on gain in a degenerate electron hole plasma. This supports the recent interpretation of gain mechanism in ZnO nanowires in terms of exciton scattering processes.

The sample

Quality factor:

Q~300 (PL)

Q~450 (µPL)

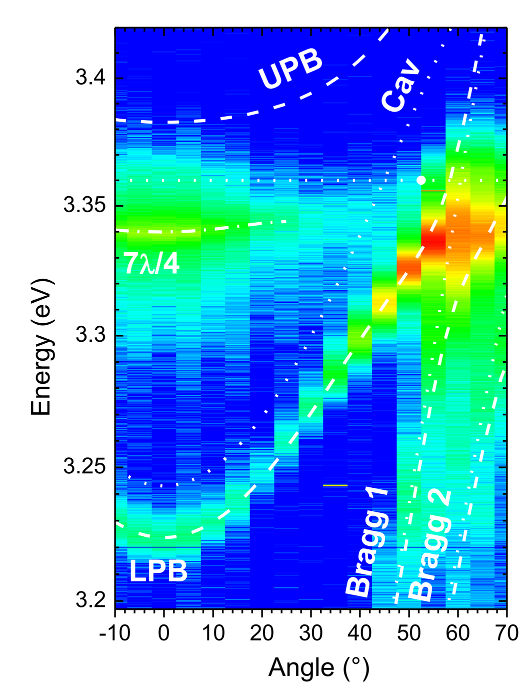
Growth:

- **SiN/SiO_2 mirror (PECVD) :** ***S. Bouchoule (LPN)***
- **ZnO active layer (MBE) :** ***J. Zúñiga-Pérez (CRHEA)***
- **Nitride mirror (MBE) :** ***E. Frayssinet (CRHEA)***

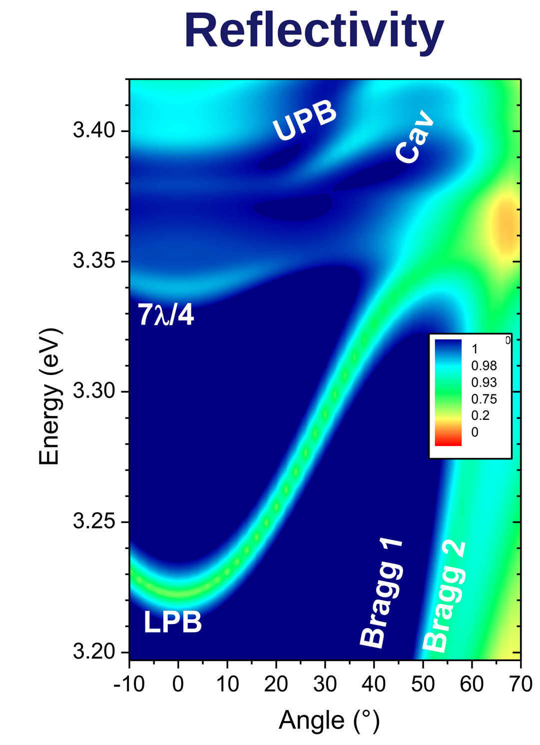
Linear Spectroscopy

Strong exciton-photon coupling regime both at low and room temperature

Angle resolved PL



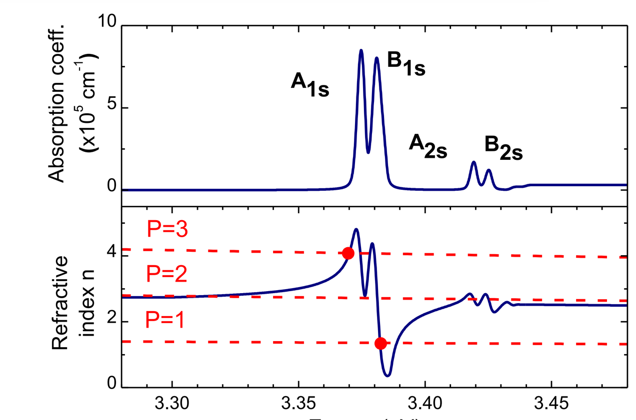
Simulated TM Reflectivity



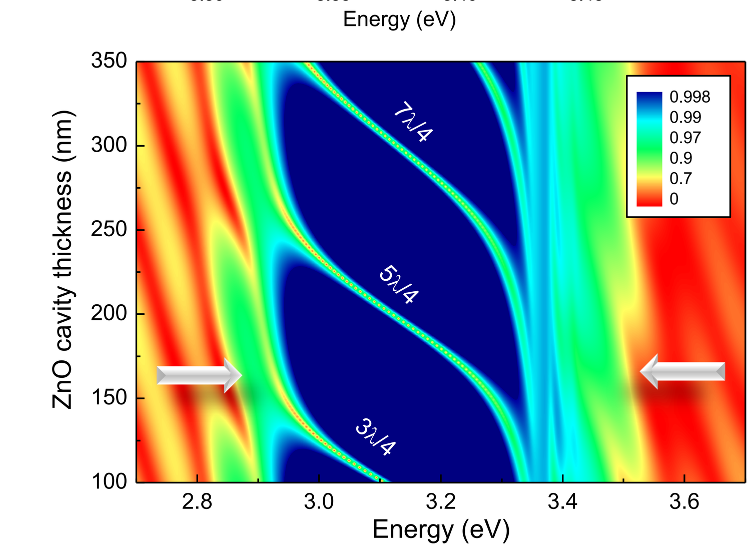
Rabi Splitting : Ω = 120meV

High order mode of the cavity : 7λ/4

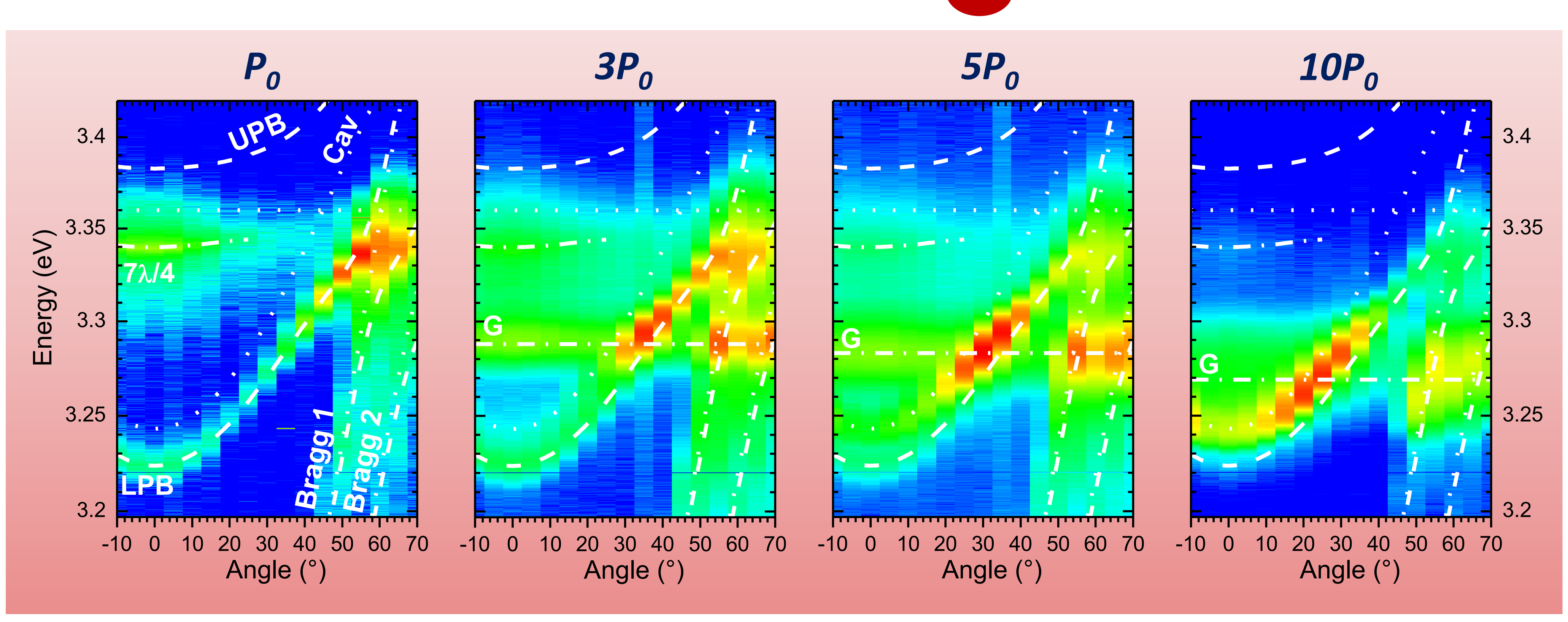
- **Due to the variation of the refractive index nearby the excitonic transitions in ZnO**



$$n_{ZnO}(\lambda)\, d_{ZnO} = \frac{P + \frac{1}{2}}{2}\lambda$$

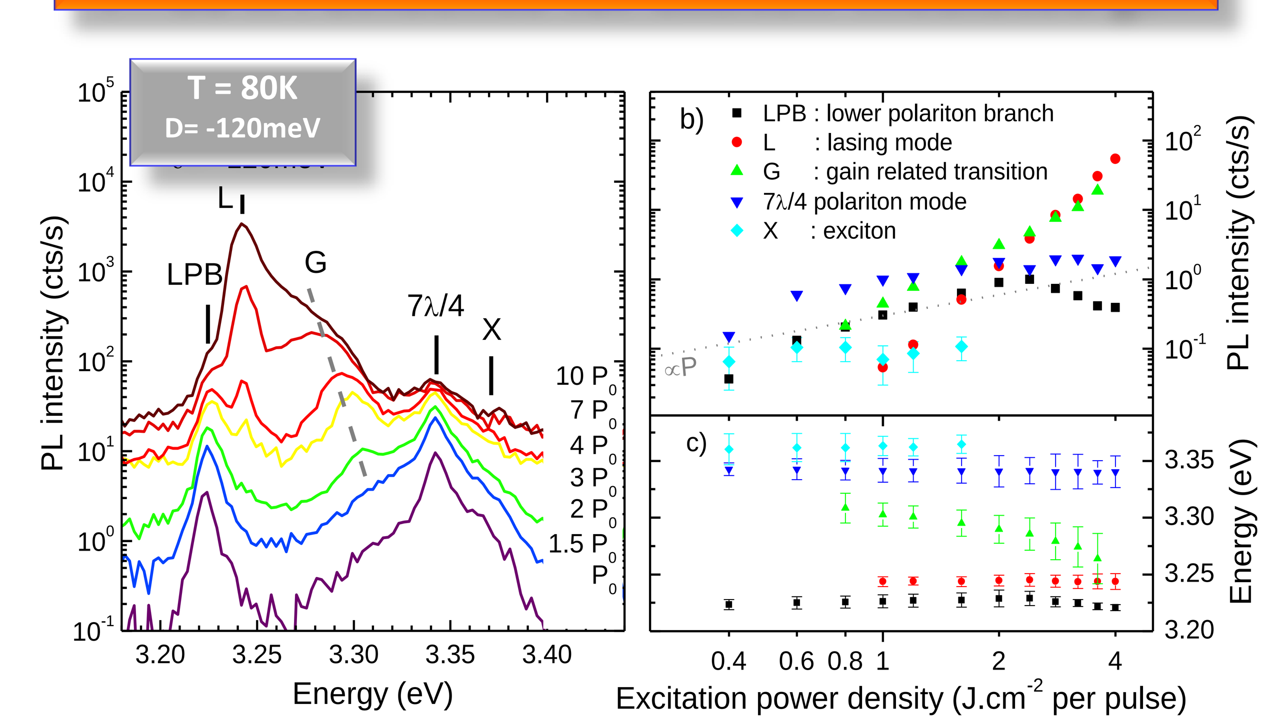


Non linear emission

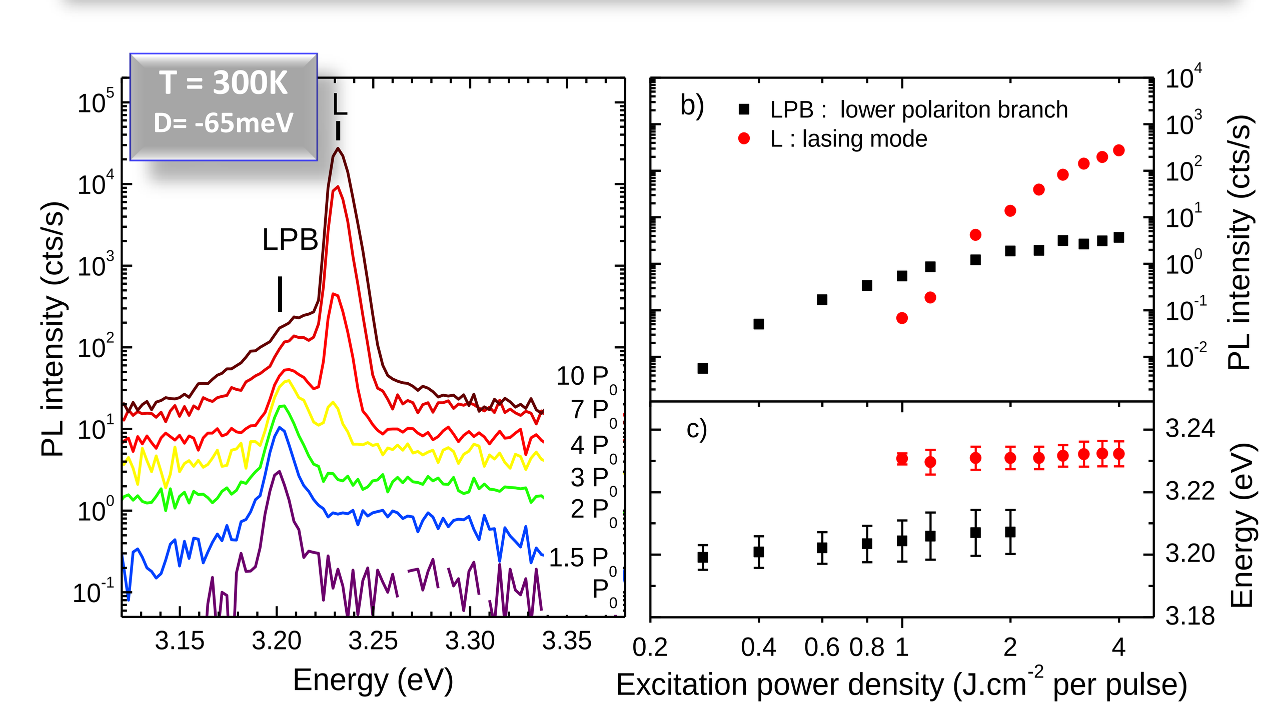


Laser OPO, 3.78 eV, 3ns, rep. rate 10Hz / Spot diam. 50µm P_0=0.4 J/cm²

T= 80 K : Evidence for exciton-mediated gain



T= 300 K : Still LASING !

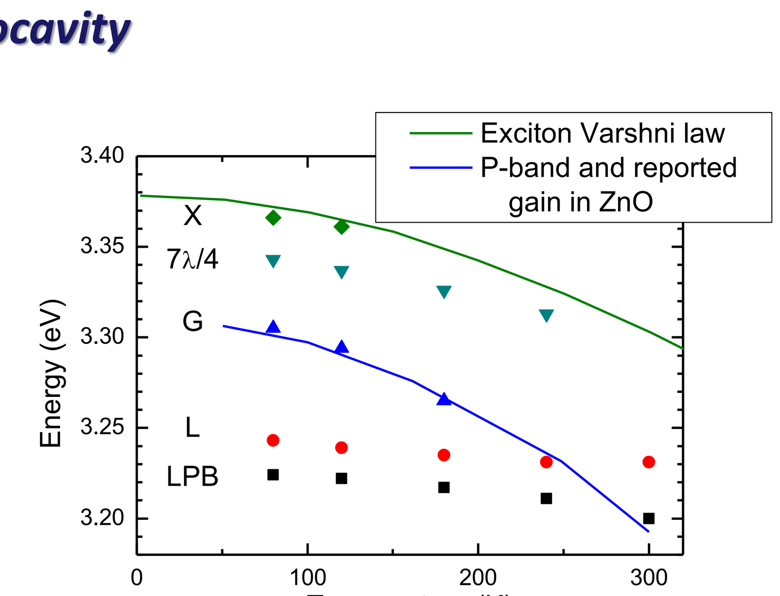


Gain transition (G)

- **Starting energy does not depend on the cavity detuning and shifts to low energy as the temperature is increased**
- **Similar in bulk ZnO to *exciton-exciton scattering processes* (P-band) at low Temp. and low density, and *gain in the electron-hole plasma* (EHP) at higher density**
- **Attribute to *random lasing in the plane of the cavity***

Lasing transition (L)

- **At the energy of the uncoupled cavity mode -> the microcavity transits into the *weak coupling regime***
- **Strong non-linearity of the peak intensity versus excitation power : *lasing is observed in the microcavity***



Appl. Phys. Lett. 98, 211105 (2011)

This work was funded by :
ANR project "ZOOM" (ANR-06-BLAN-0135)
European project Clermont4 (FP7-PEOPLE-ITN-2008 235114)

LABORATOIRE CHARLES COULOMB UMR 5221 CNRS-UM2
Dépt. Semiconducteurs, Matériaux et Capteurs (SMC)
Université Montpellier 2 – Place Eugène Bataillon – CC074
F-34095 Montpellier Cedex 5 – France
www. Coulomb.univ-montp2.fr