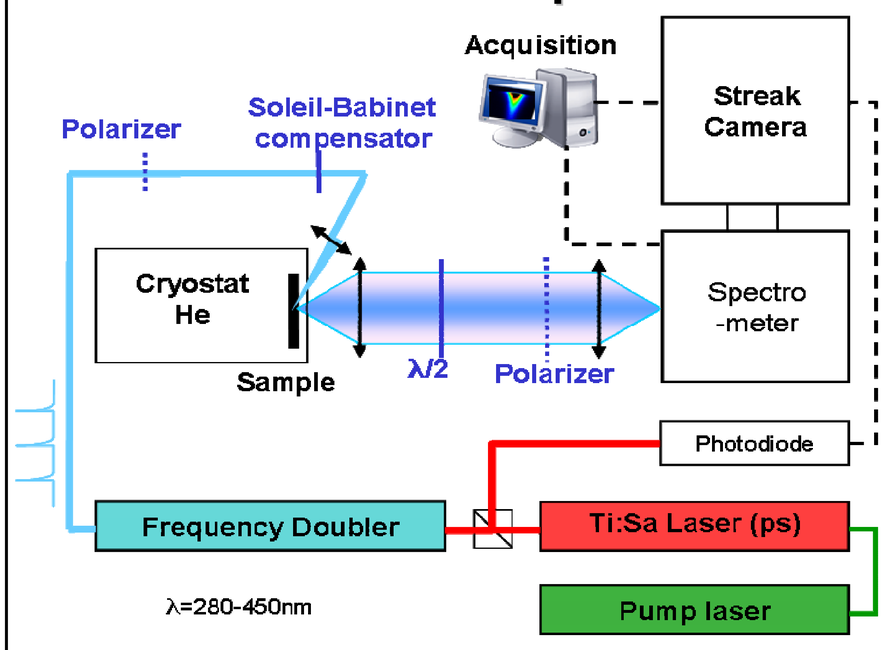
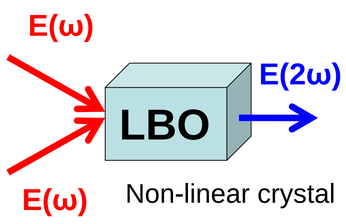
Spin dynamics in wide band-gap semiconductors

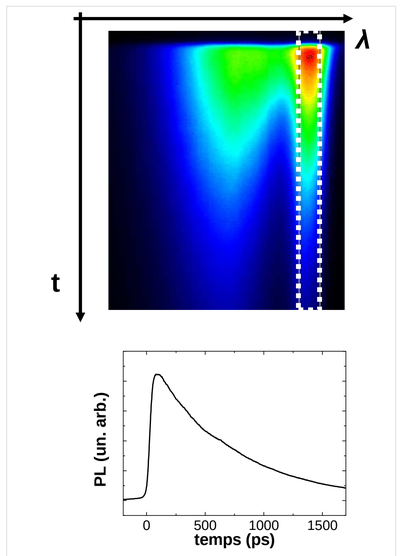
Quantum Optoelectronics Group
Laboratory for Physics and Chemistry of Nano-Objects LPCNO

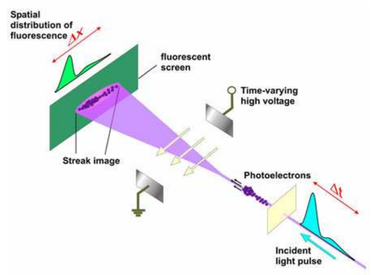
Time resolved photoluminescence



Frequency doubling







Collaborations

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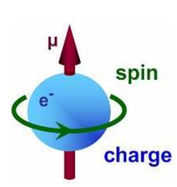
SHARP Laboratories Oxford, UK : *M. Sénès*

Spintronics



electron

charge → **Electronics**
Information stored and carried by the charge

spin (↑(up) - ↓(down)) → **SPIN-tronics**
Information stored and carried by the spin. Already used in magnetic materials:
- GMR (Hard disk)
- MRAM

In the future
Quantum Computing: the Qubit
(↑ =|0>, ↓ =|1> ou α |0> + β |1>)

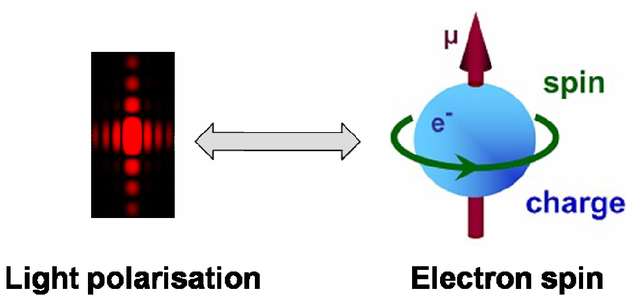
Spintronics with semicondutors :

- ❑ Possibility of tailoring doping;
- ❑ Band-gap engineering;
- ❑ Technological *savoir-faire* of the microelectronic industry

Need for stable spin polarisation

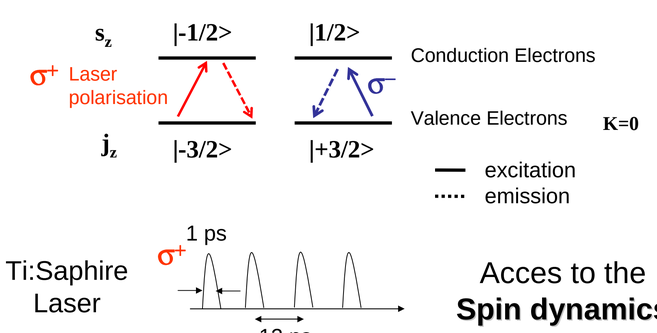
The principles:

Creation / Detection



Light polarisation — **Electron spin**

Band-to-band Optical Selection Rules



Acces to the **Spin dynamics**

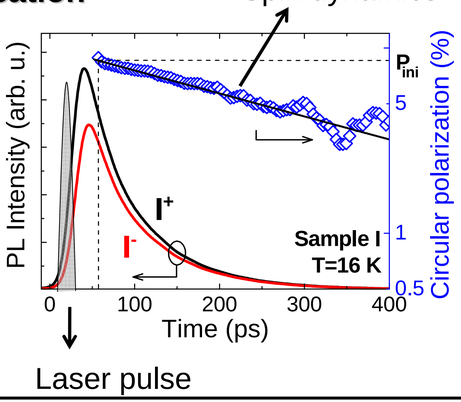
Spin polarisation

Circular polarisation :

$$P_c = \frac{I^+ - I^-}{I^+ + I^-}$$

I^+, I^- = spontaneous emission intensity (photoluminescence)

Spin dynamics



Laser pulse

Why ZnO and GaN ?

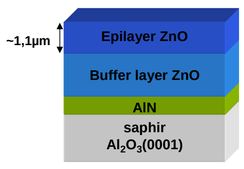
$$1/\tau_{spin}^{electron} \propto f(\Delta_{SO}/E_{gap}, \vec{k})$$

- ❑ Small spin-orbit interaction and large band gap
- ❑ 3D confinement → nanostructure

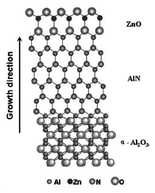
→ **expected long single particle spin relaxation time**

	E_{gap} (eV)	Δ_{SO} (meV)
ZnO	3.4	~10
GaN	3.3	~17
GaAs	1.52	~340

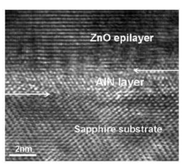
ZnO epilayer



Direction de croissance



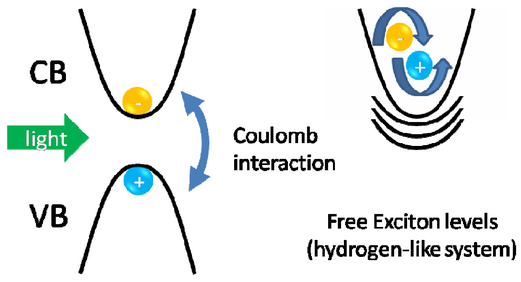
TEM image

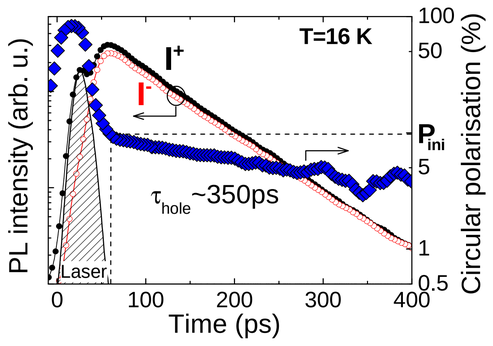


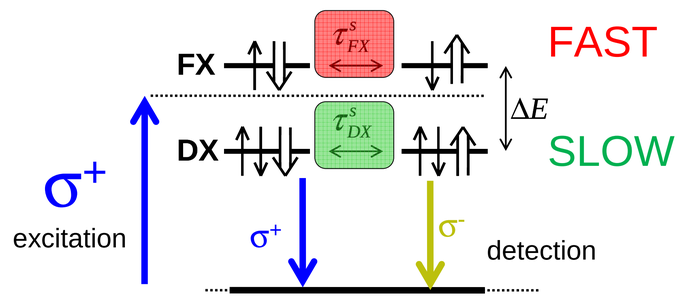
X.L. Du

IOP Beijing, China

Bound exciton polarisation :

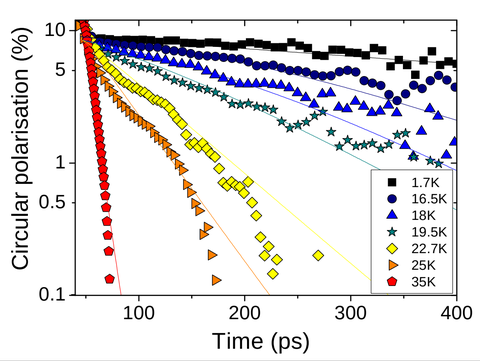






Results:

- ❑ Hole spin relaxation time ~350ps
- ❑ Free exciton spin relaxation time < 10ps



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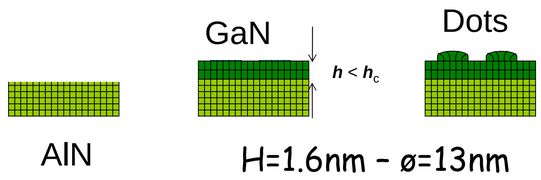
Exciton and hole spin dynamics in ZnO investigated by time-resolved photoluminescence experiments

GaN Quantum Dots

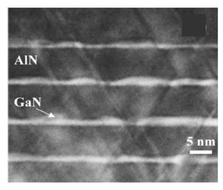
Cubic dots: No piezoelectric field

Self assembly of Quantum dots :*Stranski-Krastanov mode for GaN on AlN*

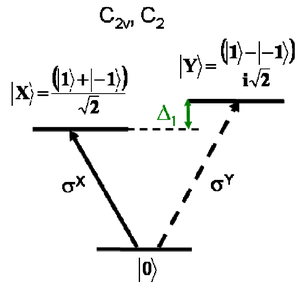


H. Mariette

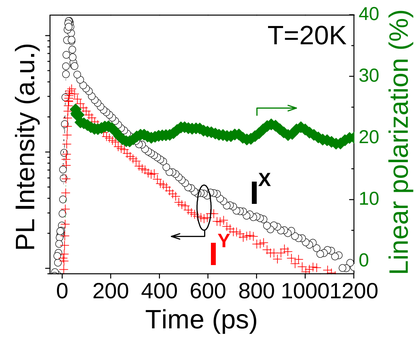
CEA-UJF Grenoble

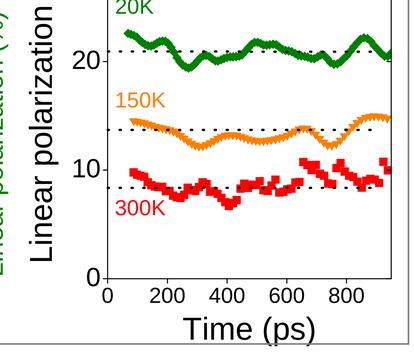


Asymmetrical dots :
C_{2v}, C_2

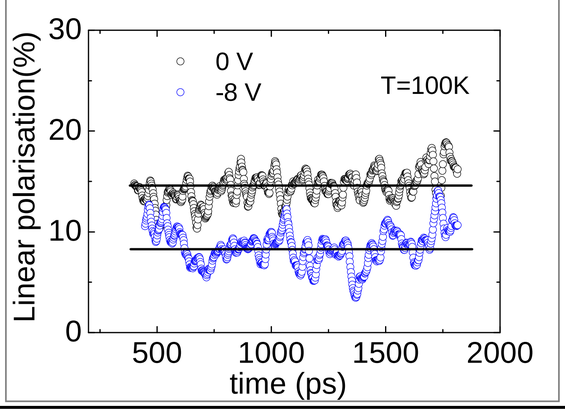


LINEAR EIGENSTATES





Wurtzite dots: piezoelectric field



Results:

- ❑ Exciton alignment at room temperature
- ❑ Polarisation control of piezoelectric dots through electric field bias

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Room-temperature optical orientation of the exciton spin in cubic GaN/AlN quantum dots

Quantum Optoelectronics Group

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