

Magnetic insulator YIG films

*preparation, magnetic static
and dynamic properties, devices*

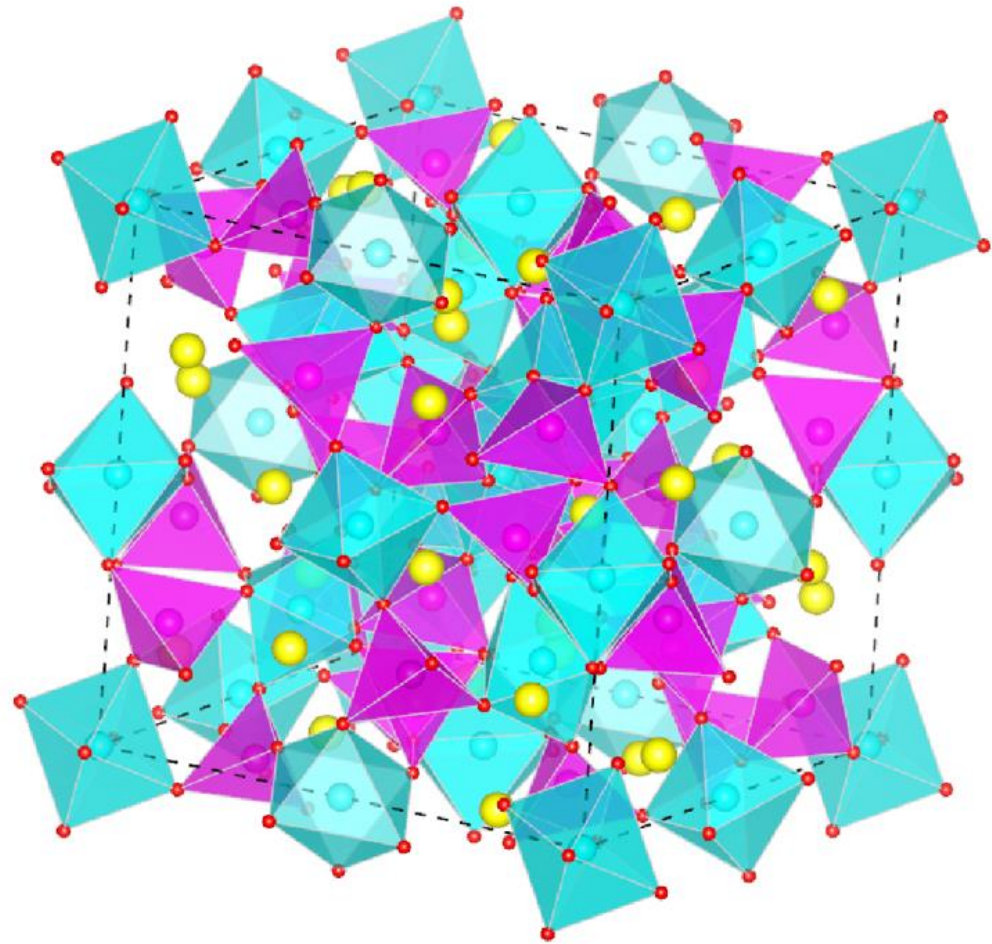
Adam Krysztofik, H. Głowiński, J. Dubowik





YIG structure



Octahedral Fe $\uparrow\uparrow\uparrow$

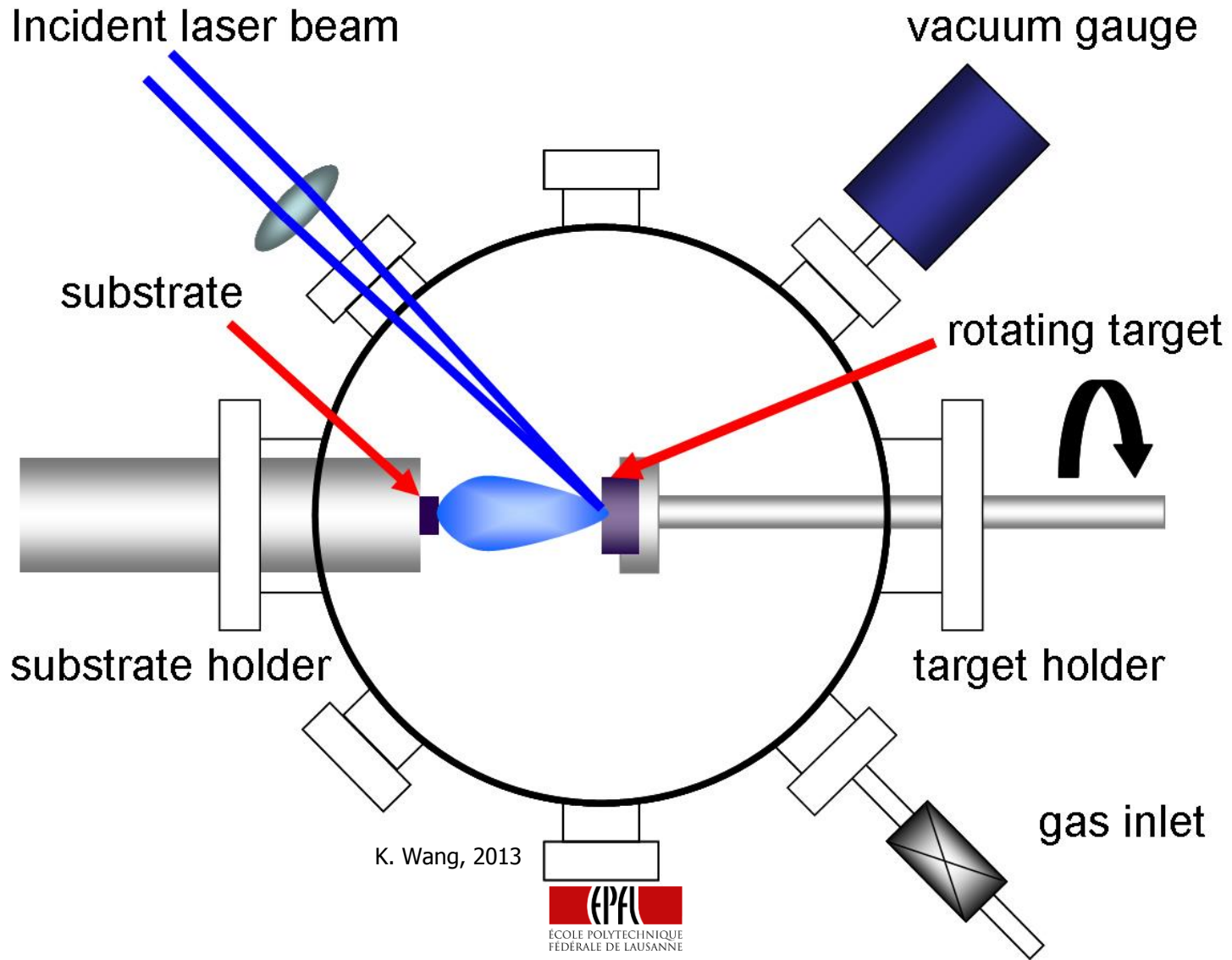
Tetrahedral Fe $\downarrow\downarrow$



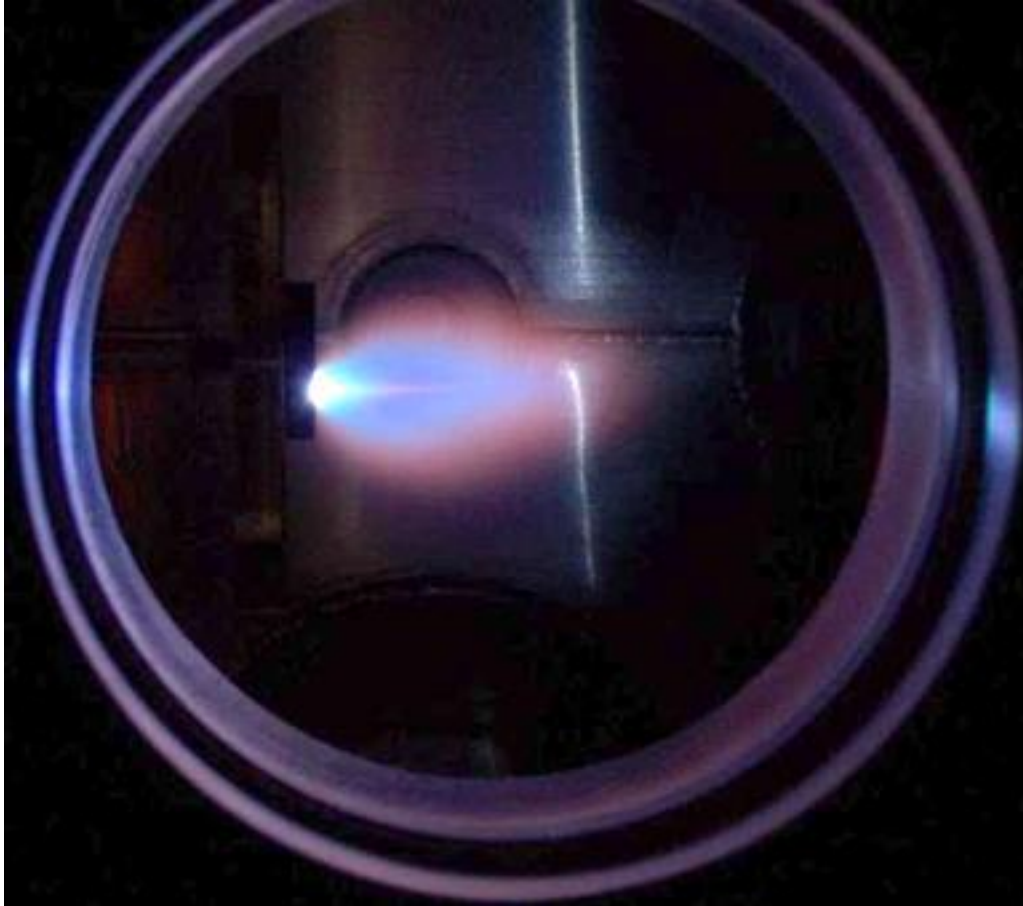
-  Y
-  octahedral Fe
-  O
-  tetrahedral Fe

H. Wang, 2015

Pulsed Laser Ablation

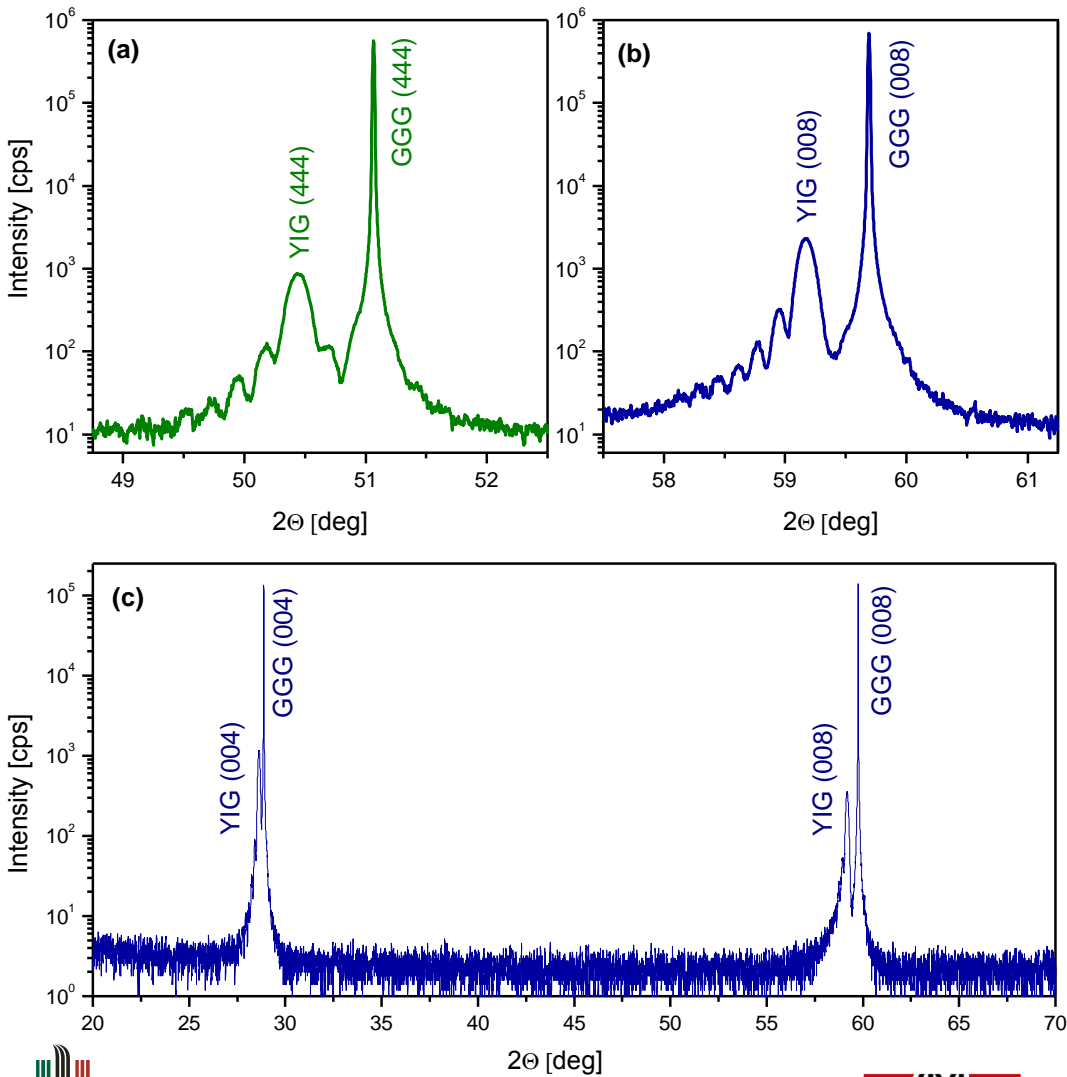


Thin films growth modes



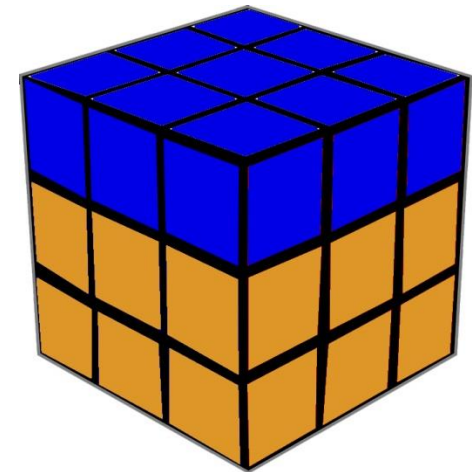
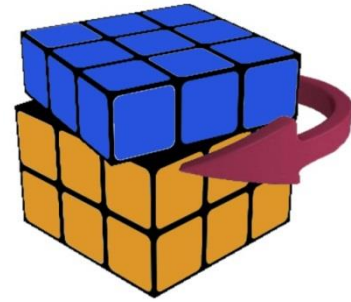
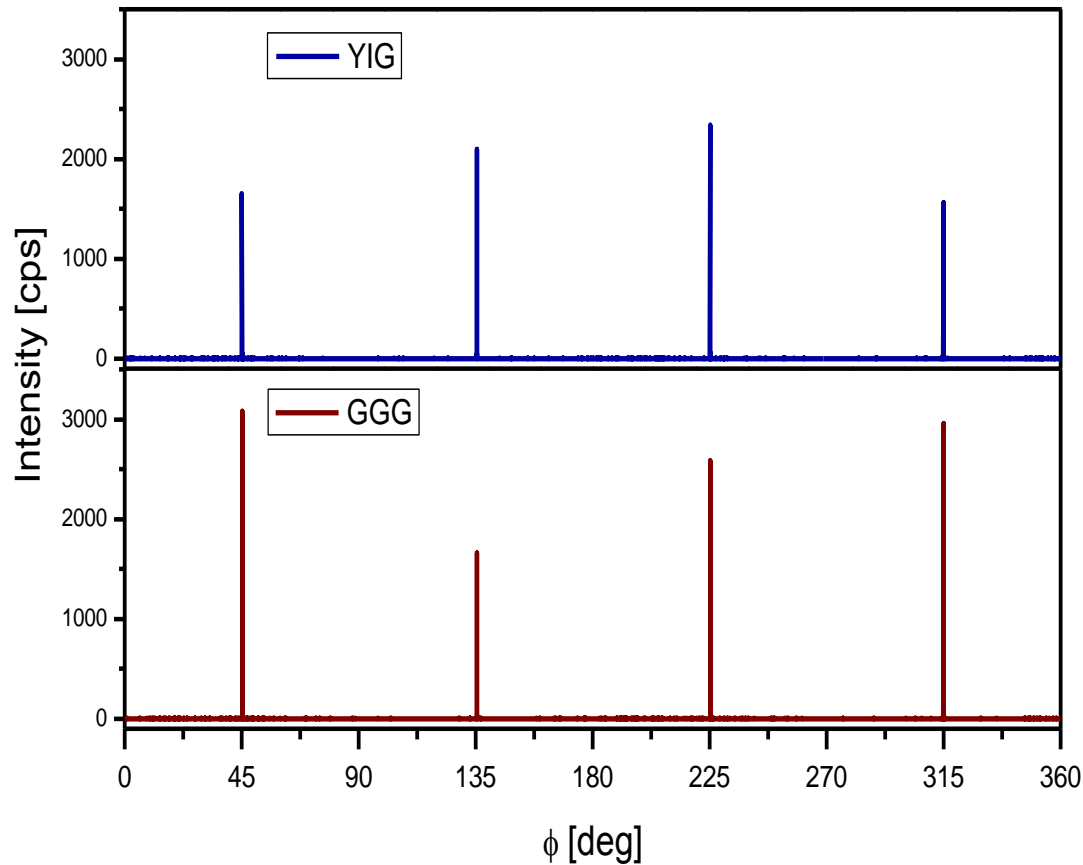
- Amorphous
- Polycrystalline
- Well-def. texture
- Monocrystalline

X-Ray Diffraction

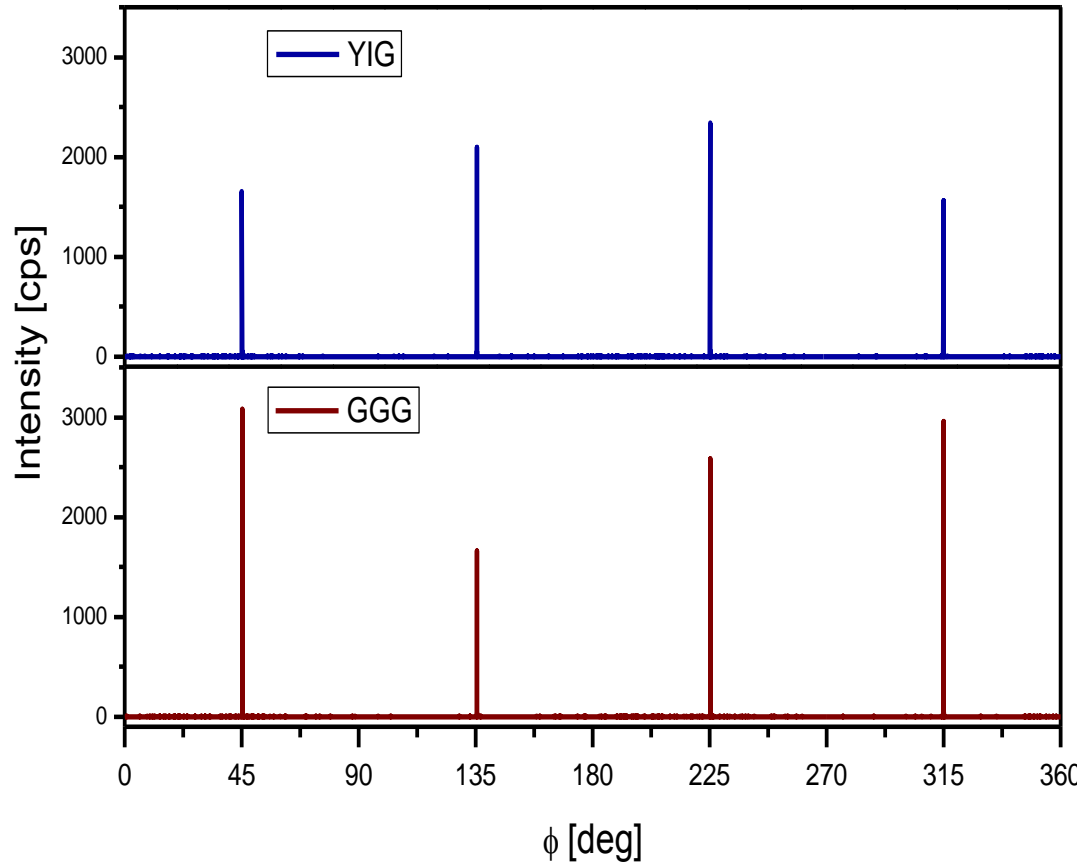


- Amorphous
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XRD ϕ -scan

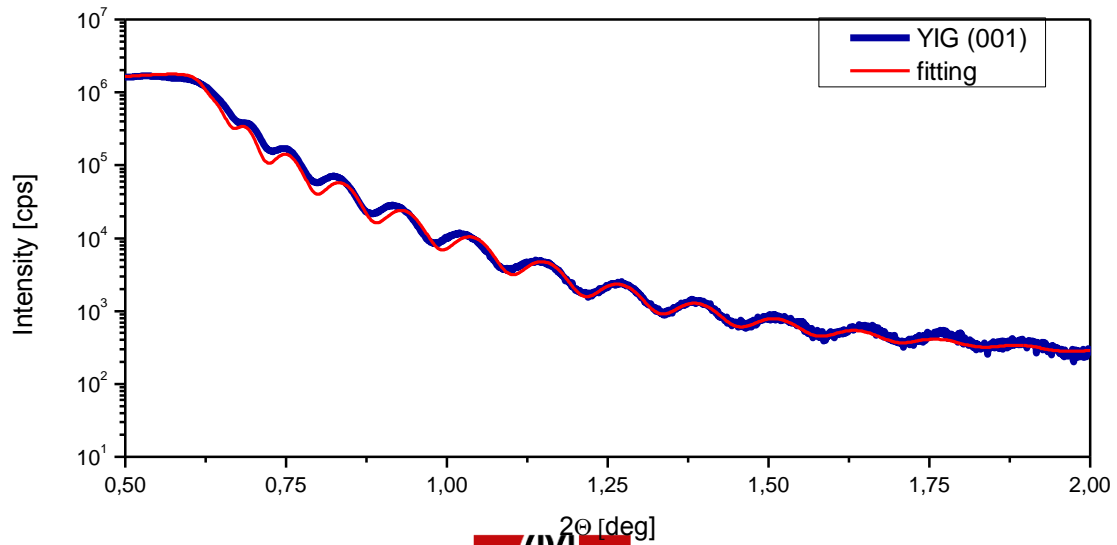
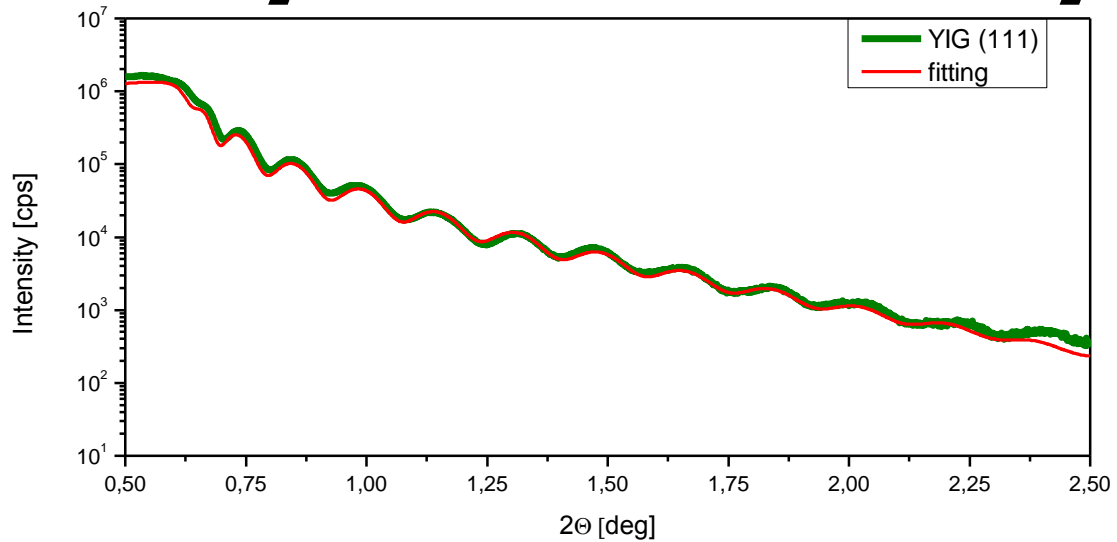


XRD ϕ -scan

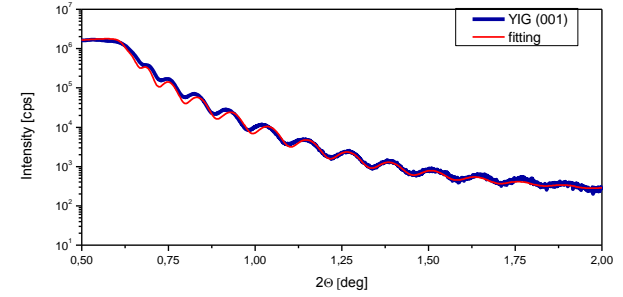
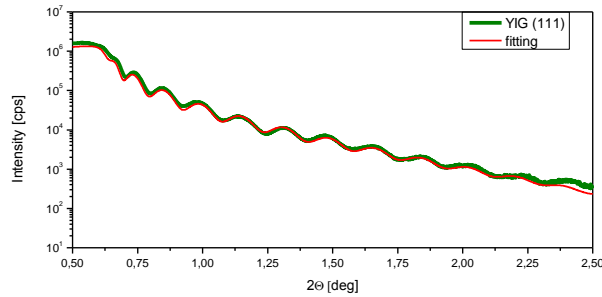


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X-Ray Reflectometry

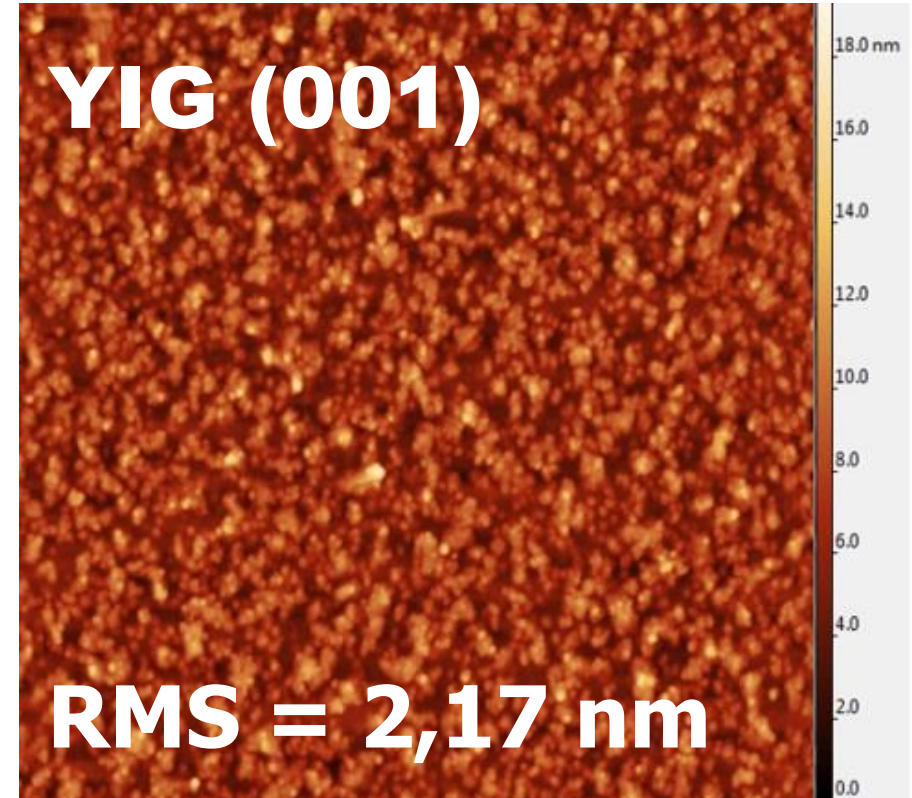
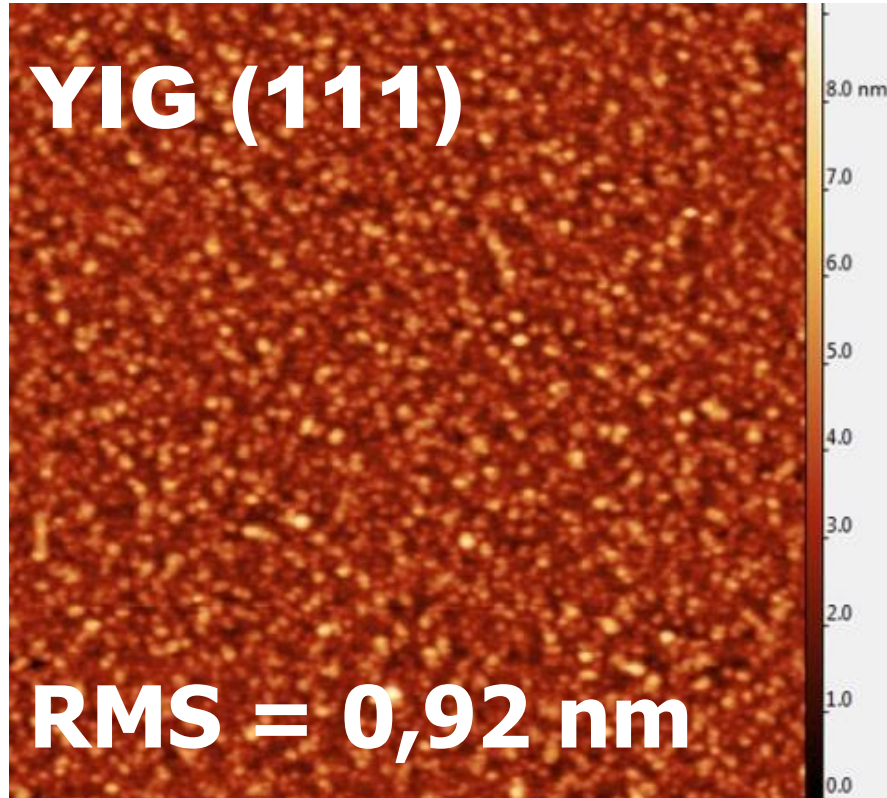


X-Ray Reflectometry



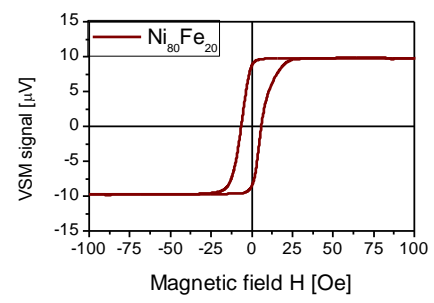
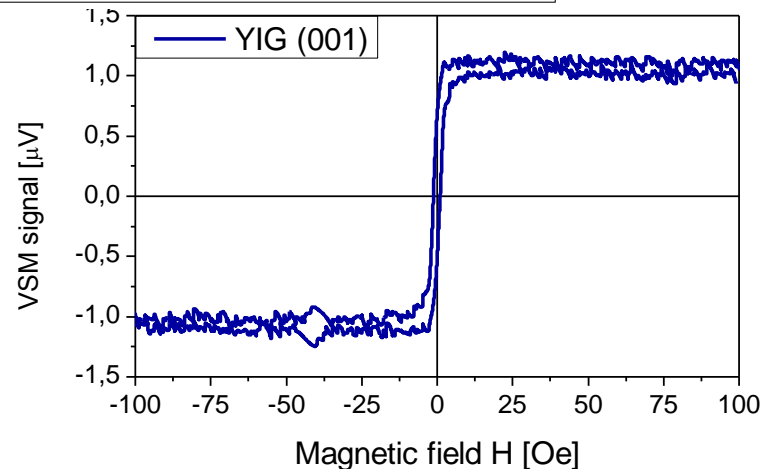
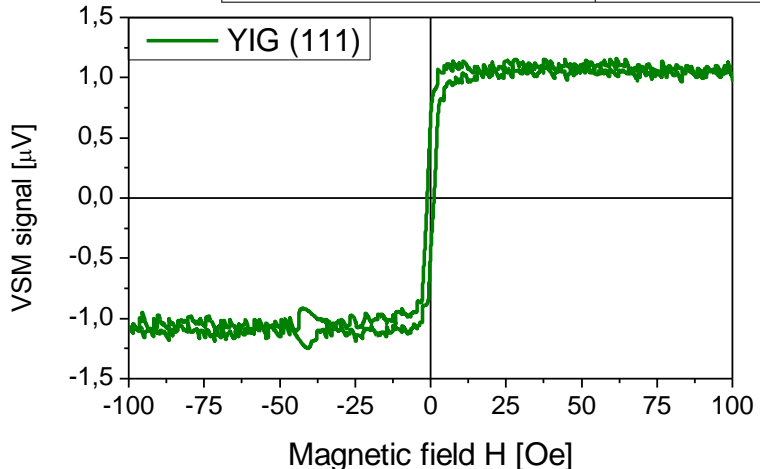
	YIG (111)	YIG (001)
Film thickness	46,1 nm ± 0,5 nm	60,0 nm ± 1,0 nm
Film roughness	0,826 nm ± 0,010 nm	2,409 nm ± 0,014 nm
Film density	5,137 $\frac{\text{g}}{\text{cm}^3}$ ± 0,013 $\frac{\text{g}}{\text{cm}^3}$	5,083 $\frac{\text{g}}{\text{cm}^3}$ ± 0,028 $\frac{\text{g}}{\text{cm}^3}$
Bulk YIG density	5,172 $\frac{\text{g}}{\text{cm}^3}$	

Atomic Force Microscopy



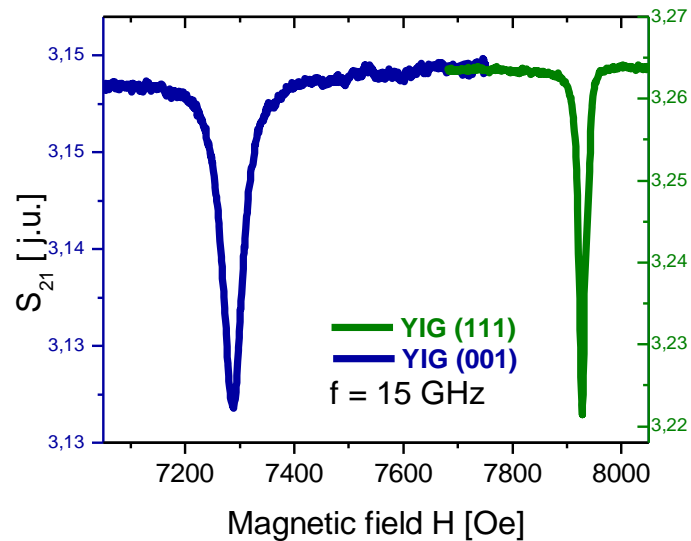
Vibrating Sample Magnetometer

	YIG (111)	YIG (001)
Coercive field	1,10 Oe ± 0,03 Oe	1,22 Oe ± 0,03 Oe
Saturation magnet. M_s	$149 \frac{\text{emu}}{\text{cm}^3} \pm 9 \frac{\text{emu}}{\text{cm}^3}$	$144 \frac{\text{emu}}{\text{cm}^3} \pm 7 \frac{\text{emu}}{\text{cm}^3}$
Bulk YIG M_s	$139 \frac{\text{emu}}{\text{cm}^3}$	



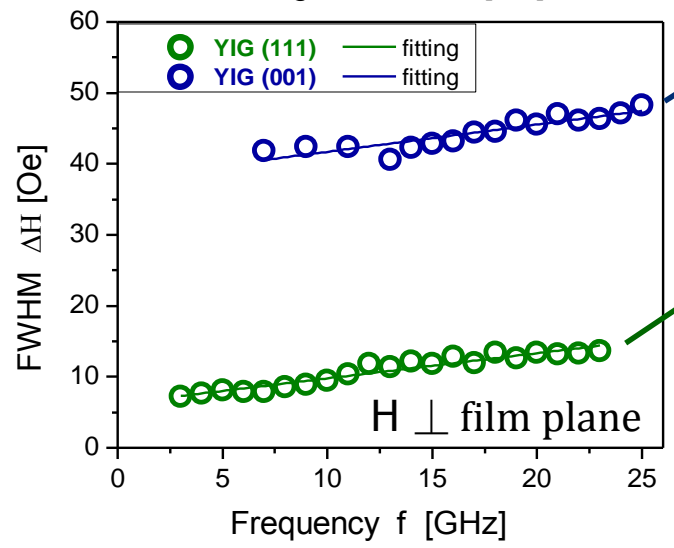
$$M_s = \frac{\varepsilon}{\varepsilon_{ref}} \frac{A_{ref}}{A} \frac{t_{ref}}{t} M_s^{ref}$$

VNA-FMR



$$\Delta H = \frac{4\pi\alpha}{\gamma} f + \Delta H_0$$

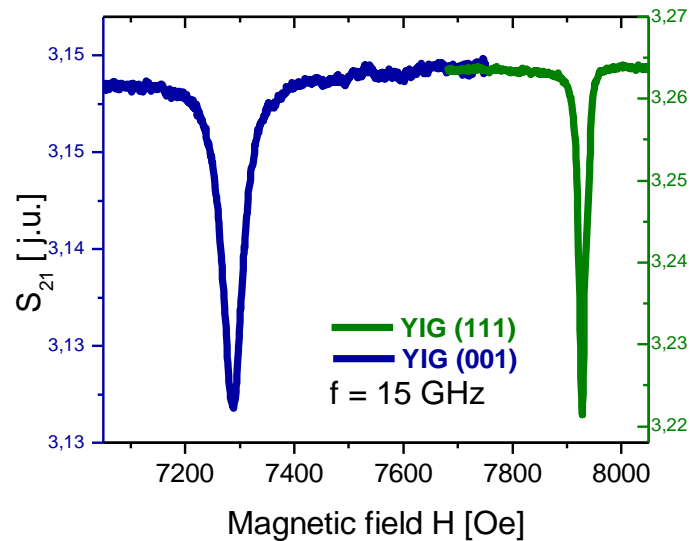
Low Gilbert damping:



$$\alpha = 5,5 \cdot 10^{-4} \pm 0,7 \cdot 10^{-4}$$

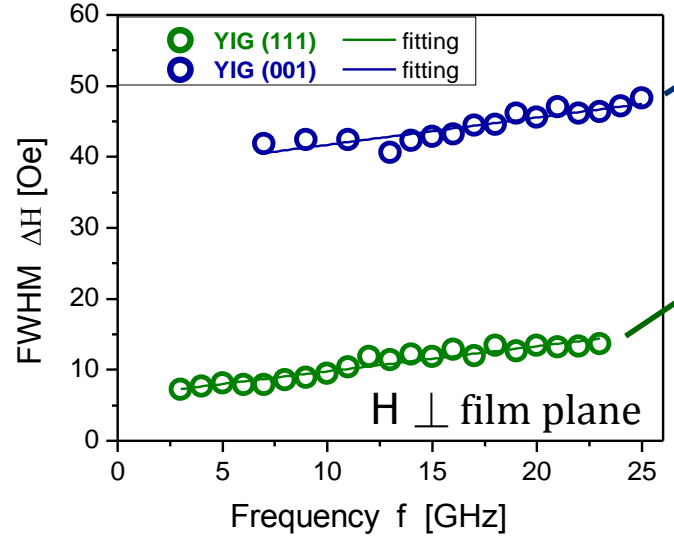
$$\alpha = 5,02 \cdot 10^{-4} \pm 0,29 \cdot 10^{-4}$$

VNA-FMR



$$\Delta H = \frac{4\pi\alpha}{\gamma} f + \Delta H_0$$

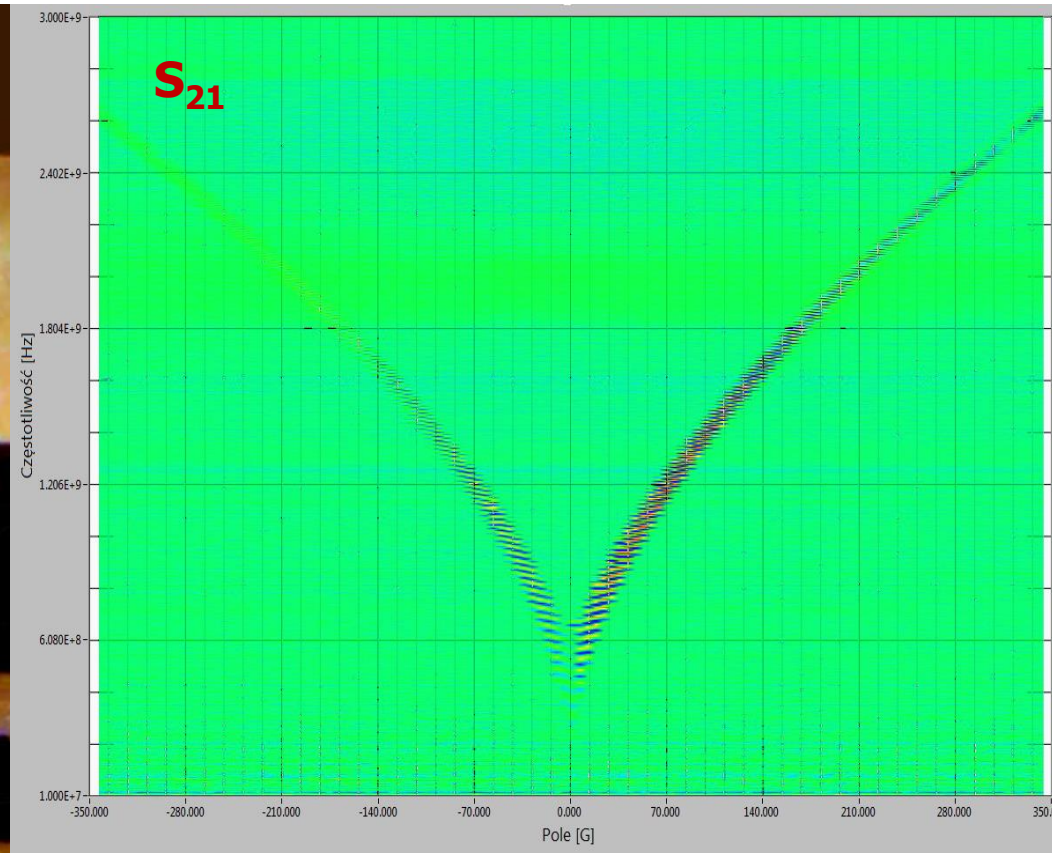
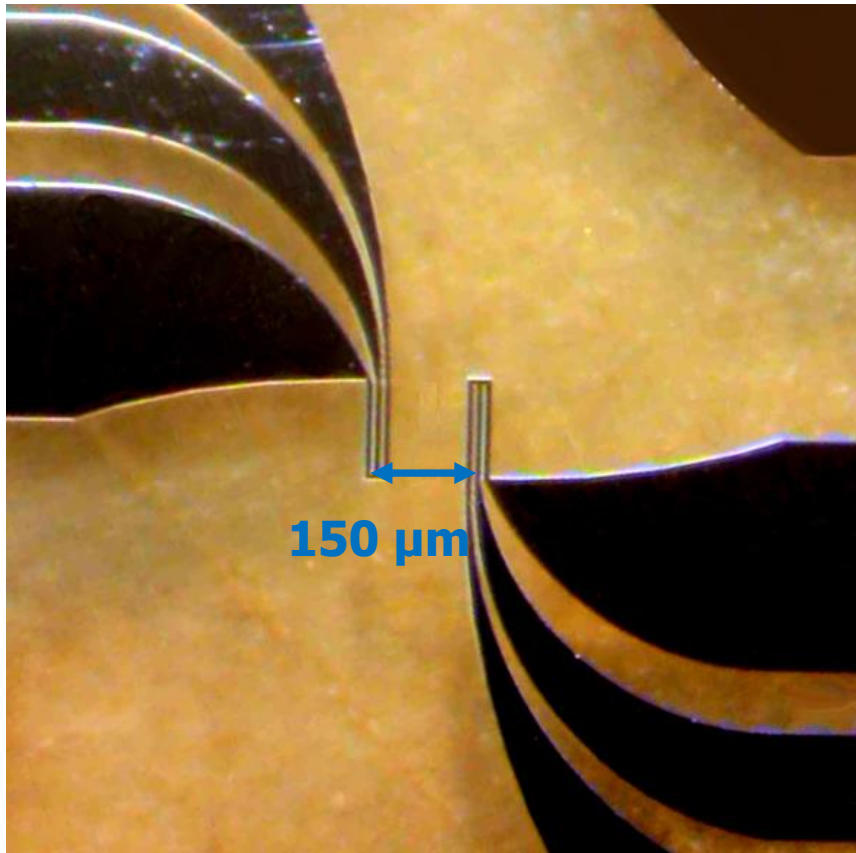
Low Gilbert damping:



$$\alpha = 5,5 \cdot 10^{-4} \pm 0,7 \cdot 10^{-4}$$

$$\alpha = 5,02 \cdot 10^{-4} \pm 0,29 \cdot 10^{-4}$$

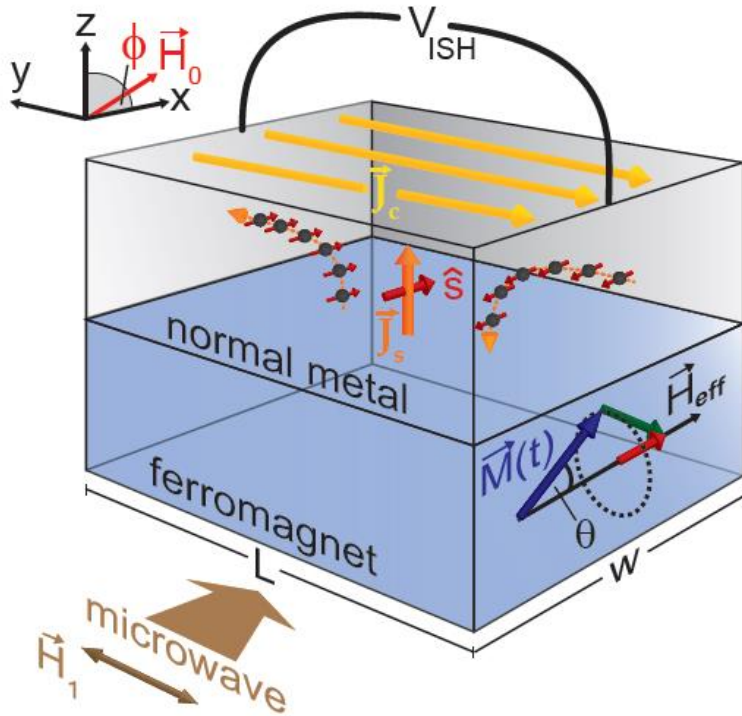
Long distance spin wave propagation



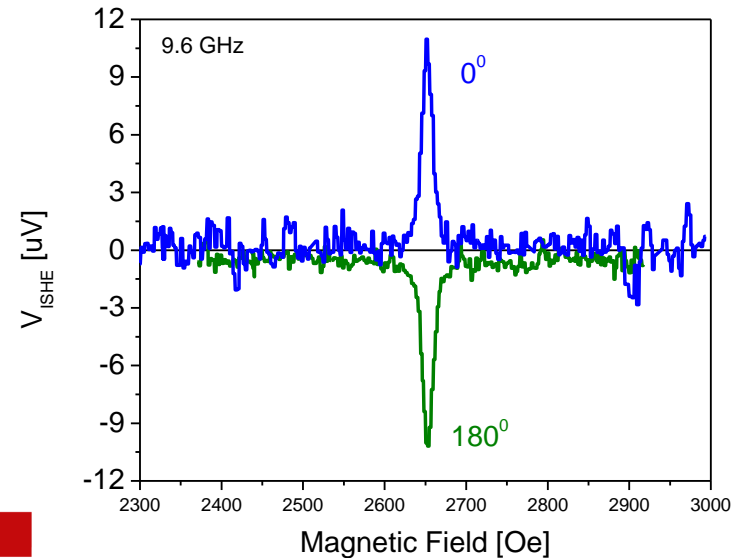
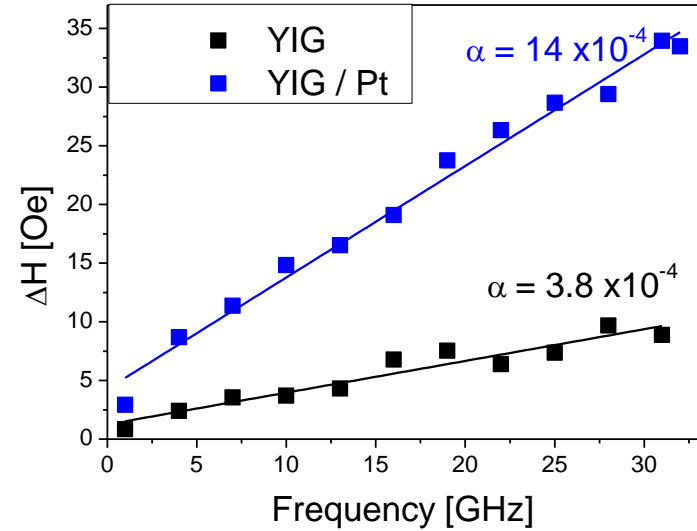
Conclusion

We are able to prepare epitaxial YIG films
with low Gilbert damping and bulk-like
magnetization

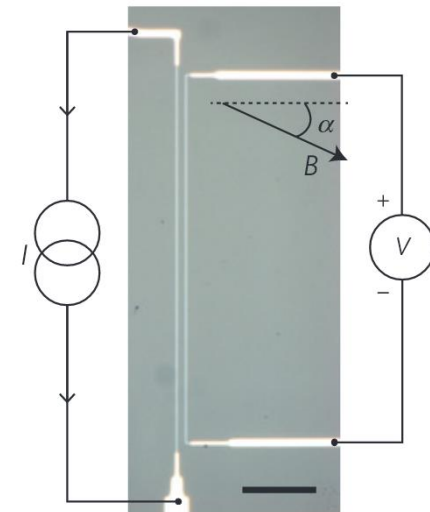
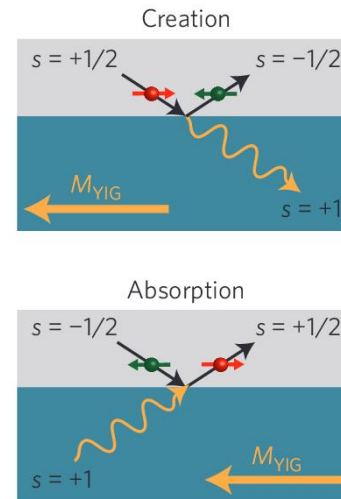
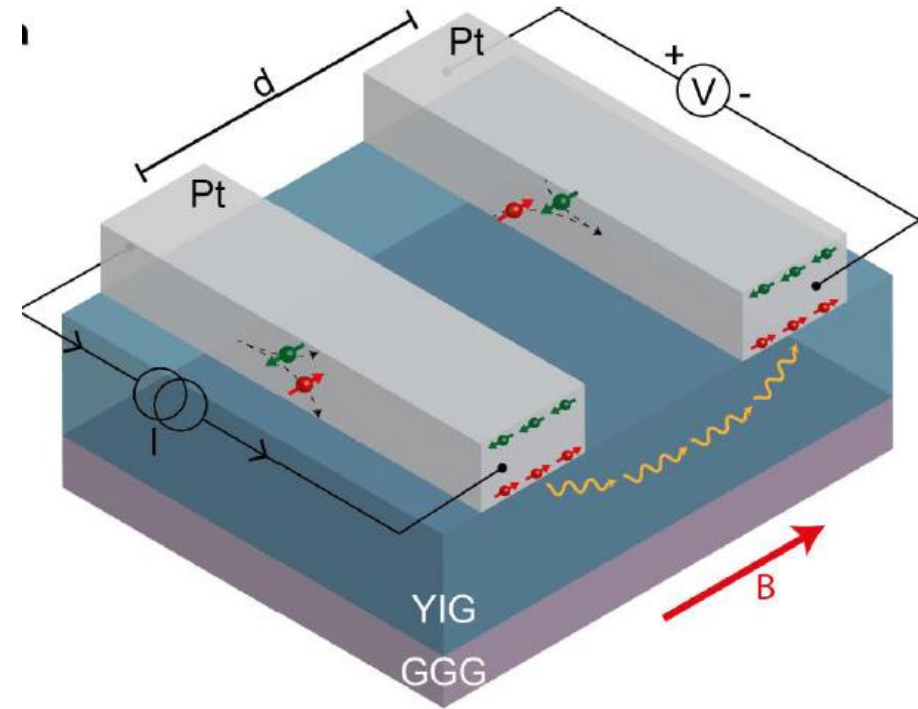
Inverse Spin Hall Effect



F.D. Czeschka, 2011



YIG / Pt device



L. J. Cornelissen et al., 2015