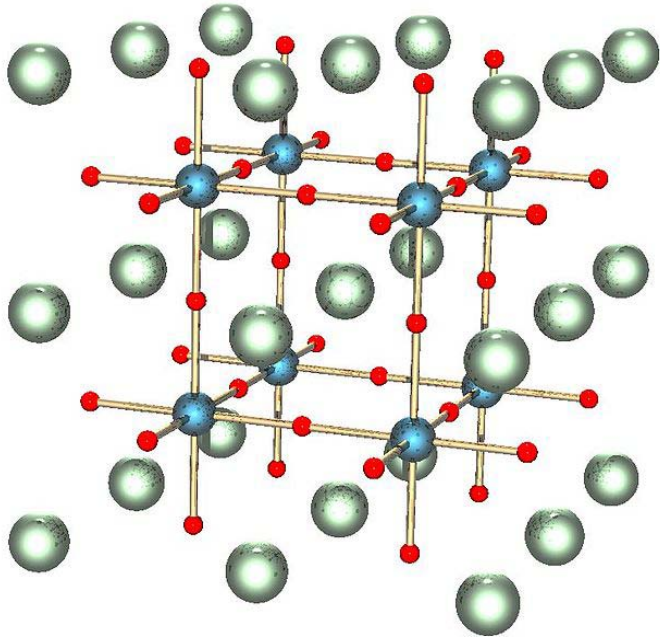


# **Hunt for magnetism in Strontium titanate**

**Olga Lobacheva**

**2013 April, 15**

# Strontium titanate $\text{SrTiO}_3$



Oxygen

Titanium  $\text{Ti}^{4+}$

Strontium  $\text{Sr}^{2+}$

Perovskite cubic structure

High dielectric constant

Indirect band gap 3.3 eV

No ferromagnetic or ferroelectric properties

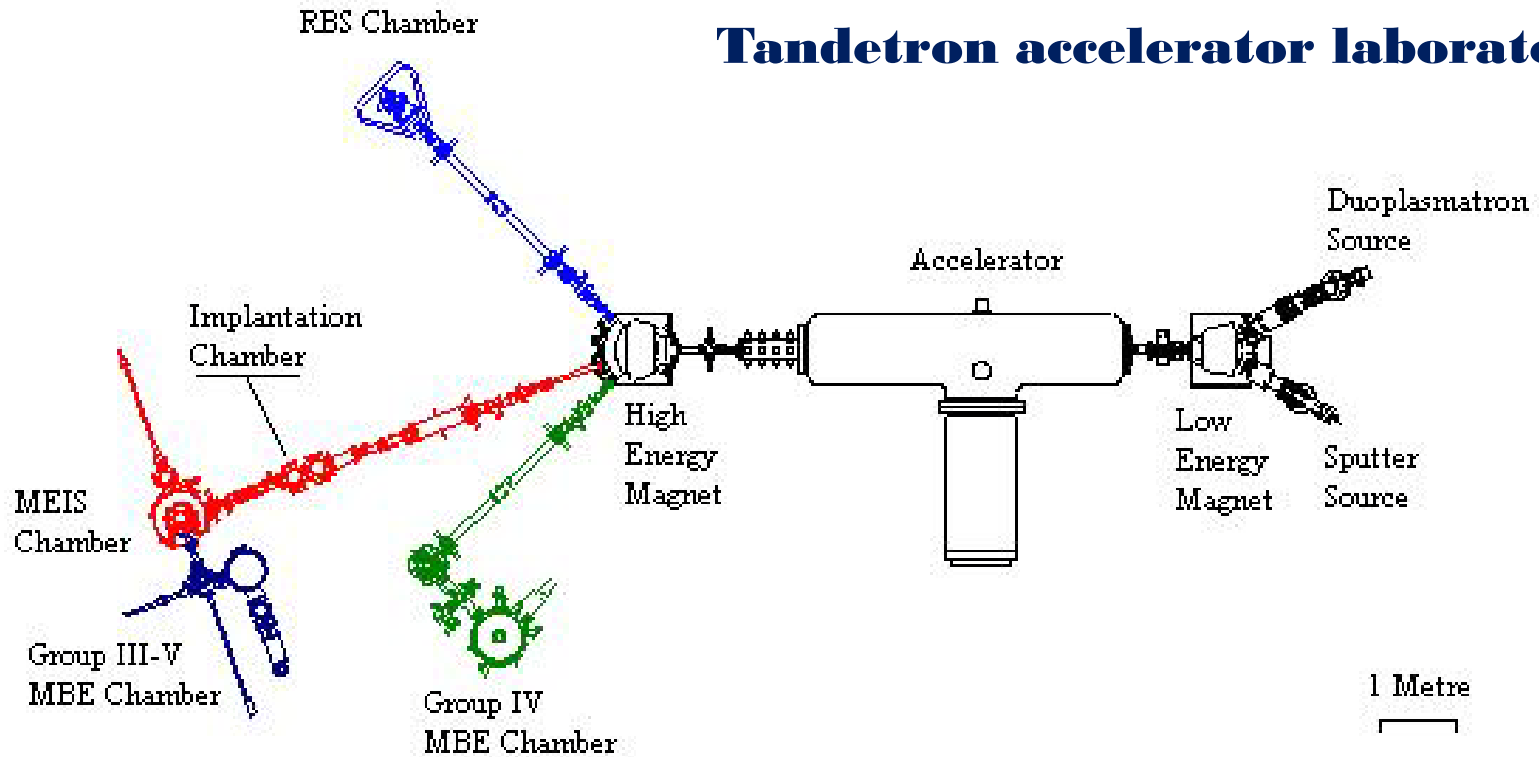
Doping: conductivity, luminescence, magnetism

Applications: gas sensors;

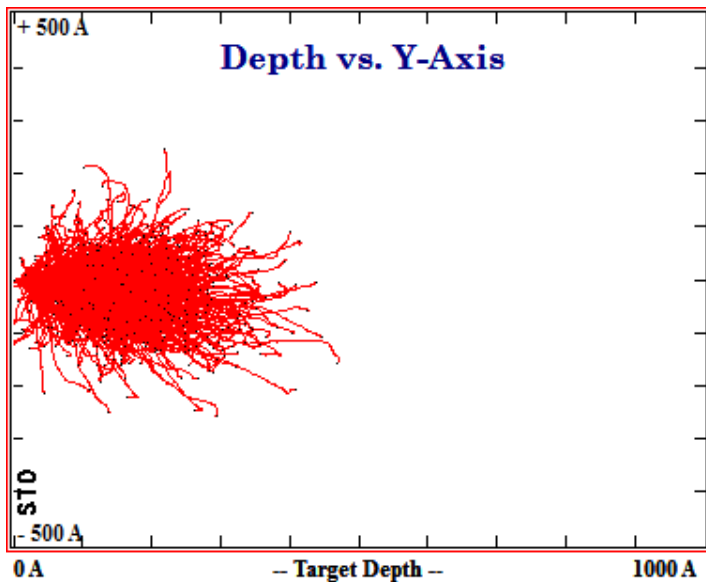
photocatalyst;

fuel cells anodes

# Tandem accelerator laboratory

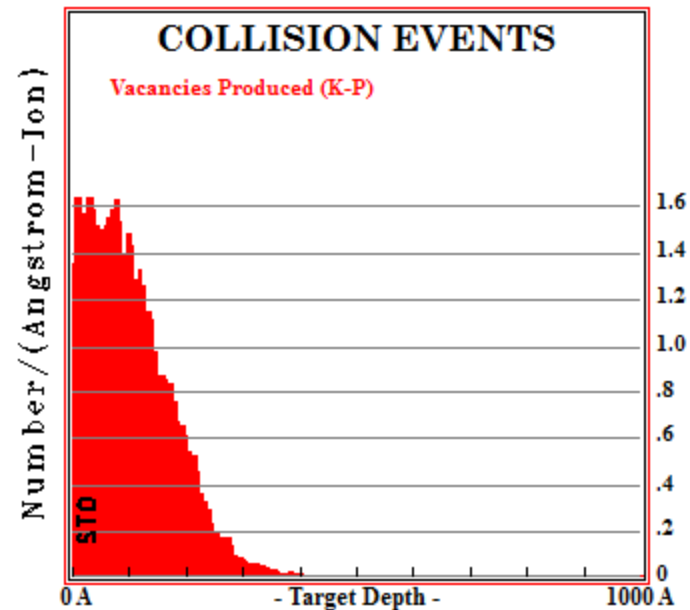
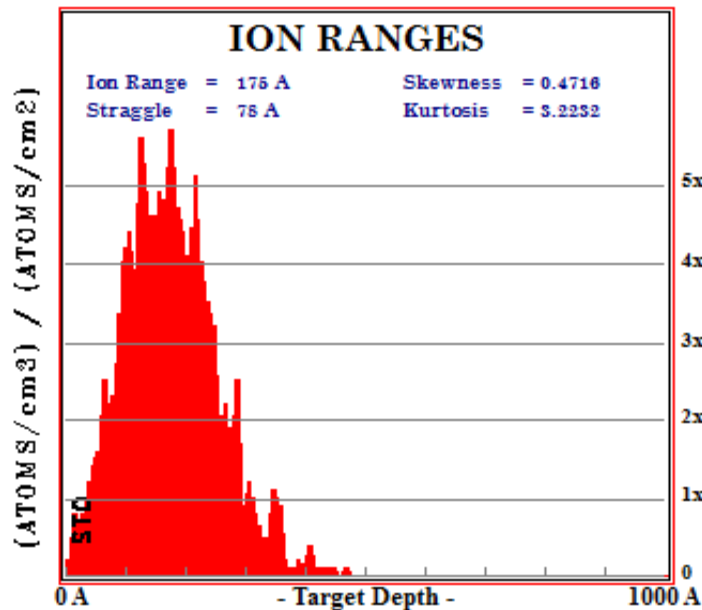


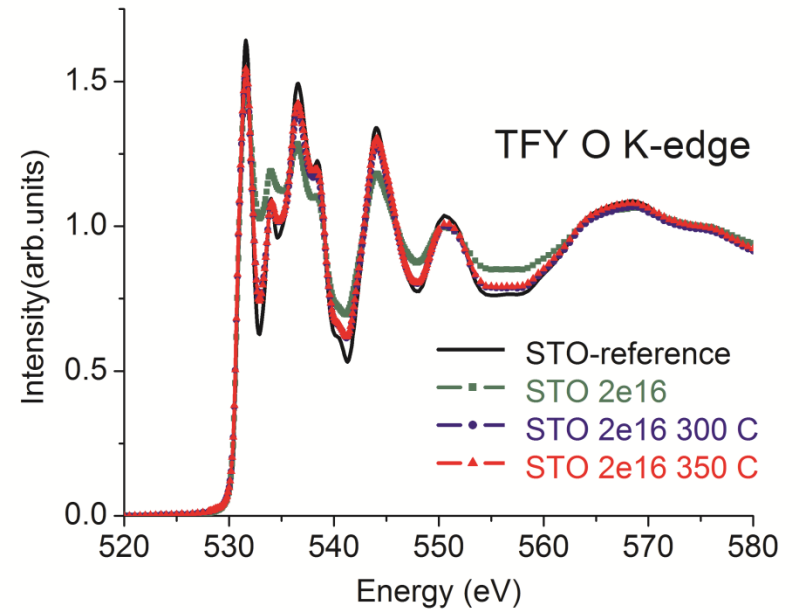
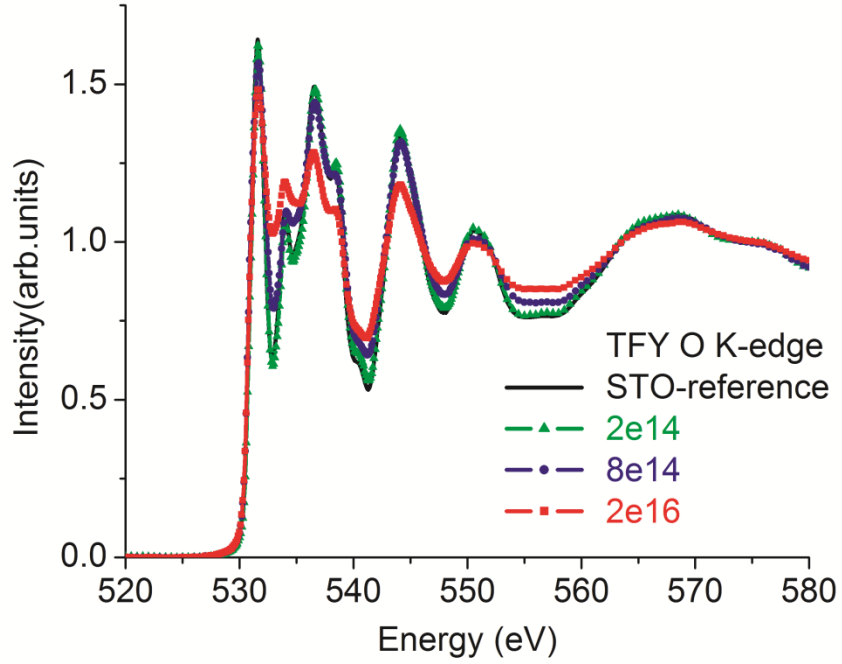
- Ion beam implantation
- Rutherford backscattering

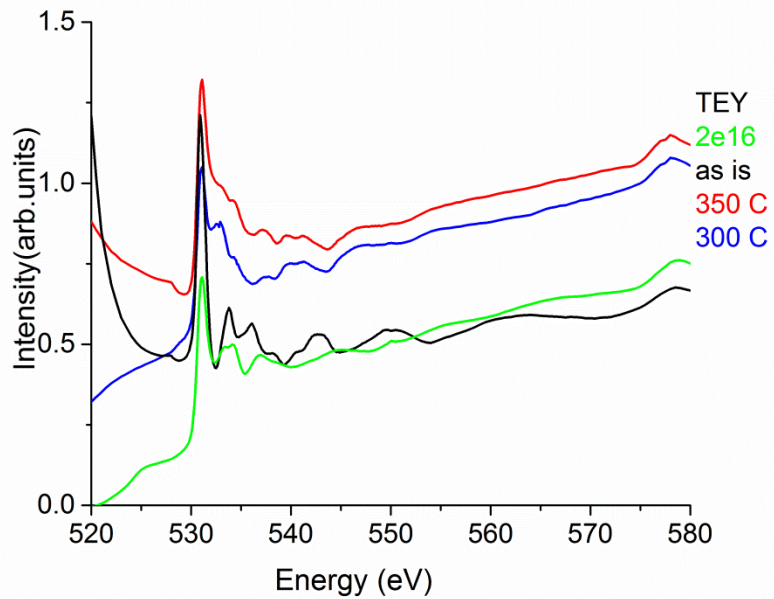
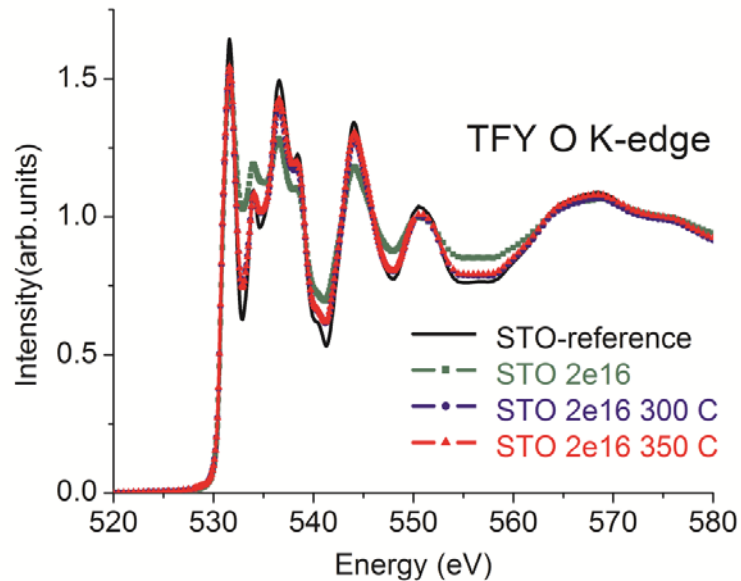
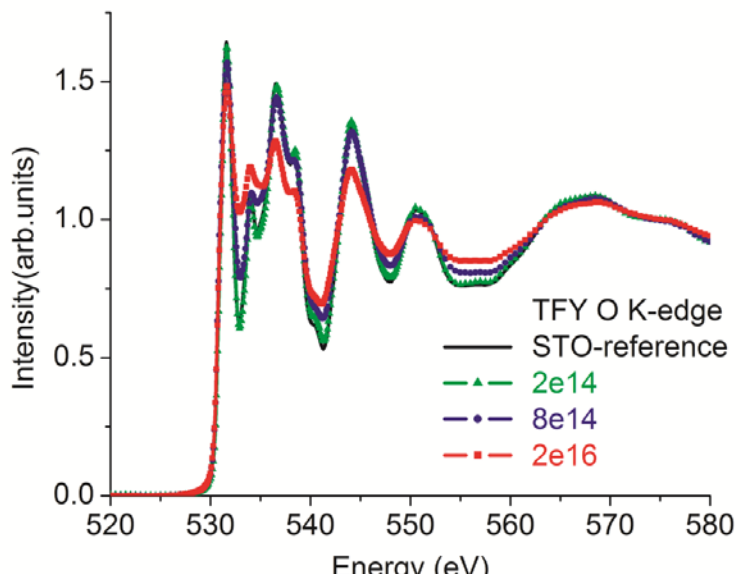


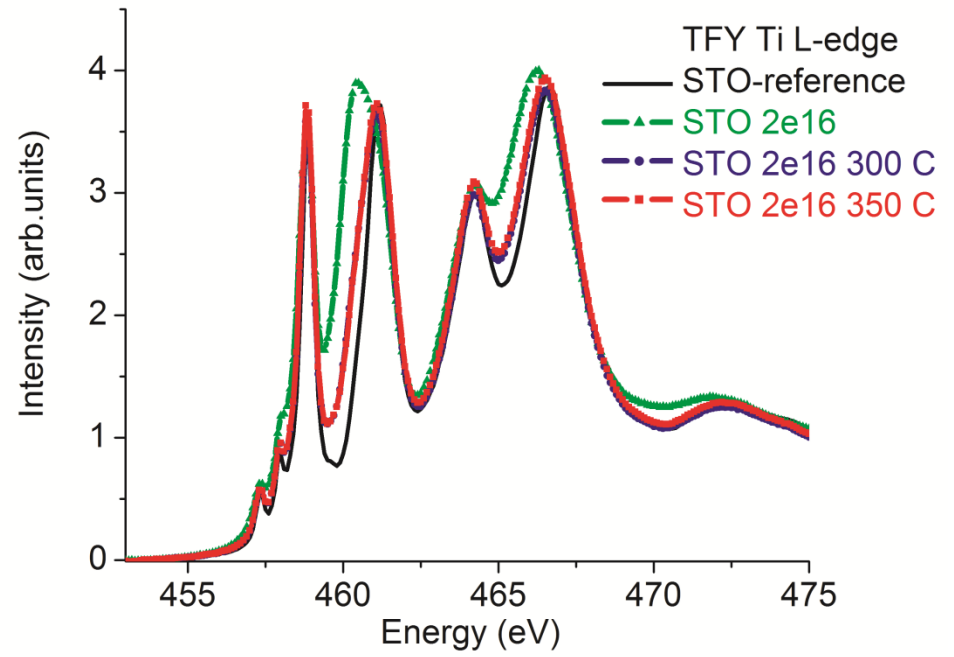
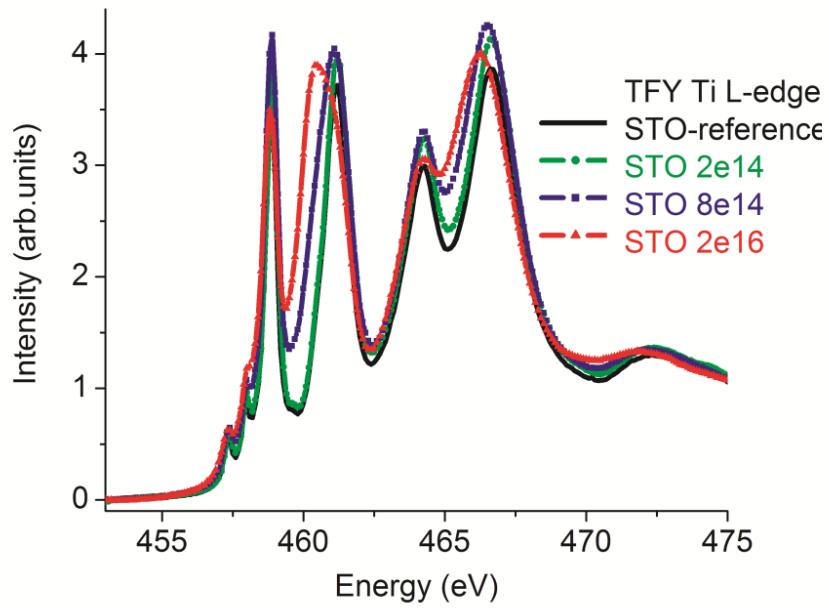
Strontium titanate was implanted with Fe<sup>+</sup> ions  
 30keV 7° off normal  
 Layer affected by implantation ~50nm  
 (with max ~20nm)

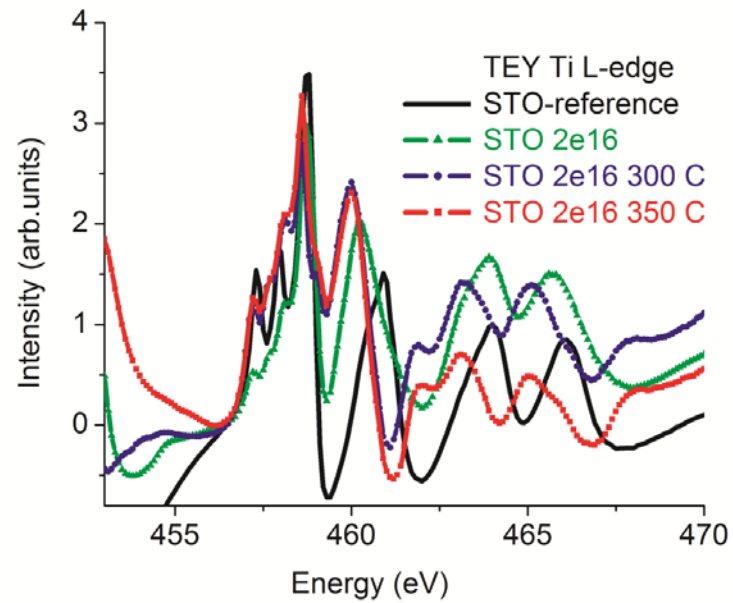
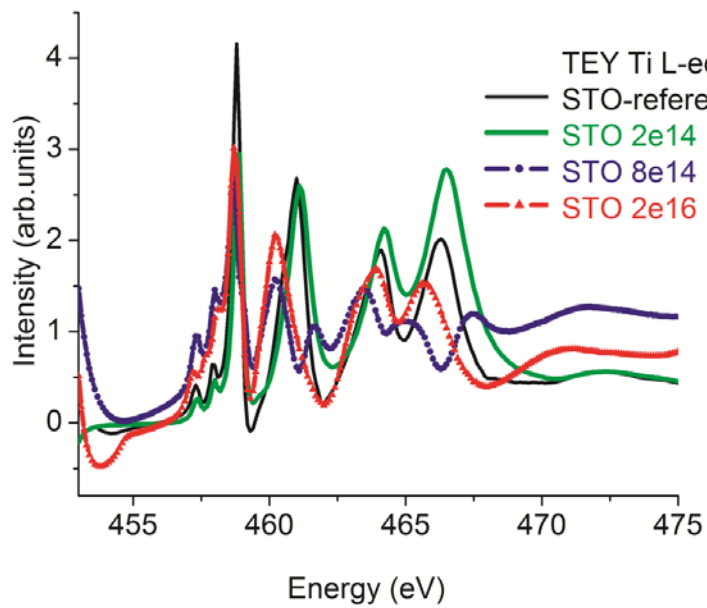
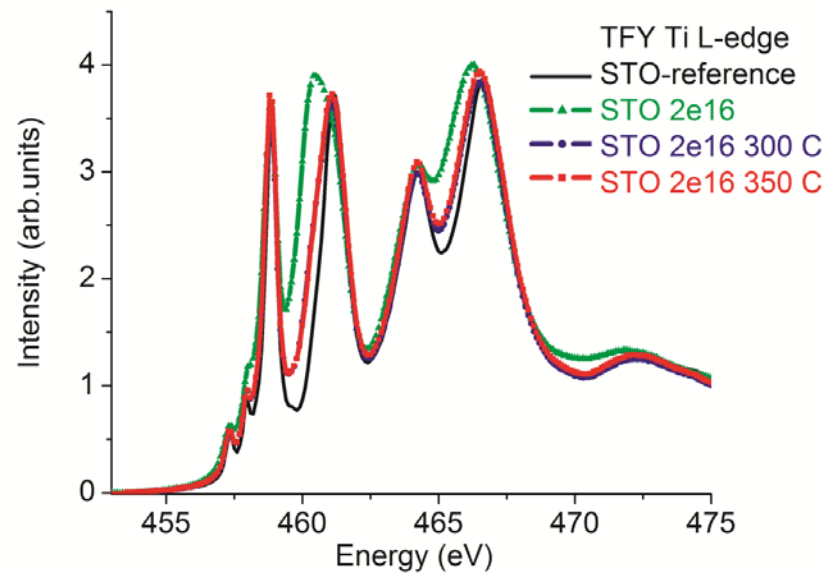
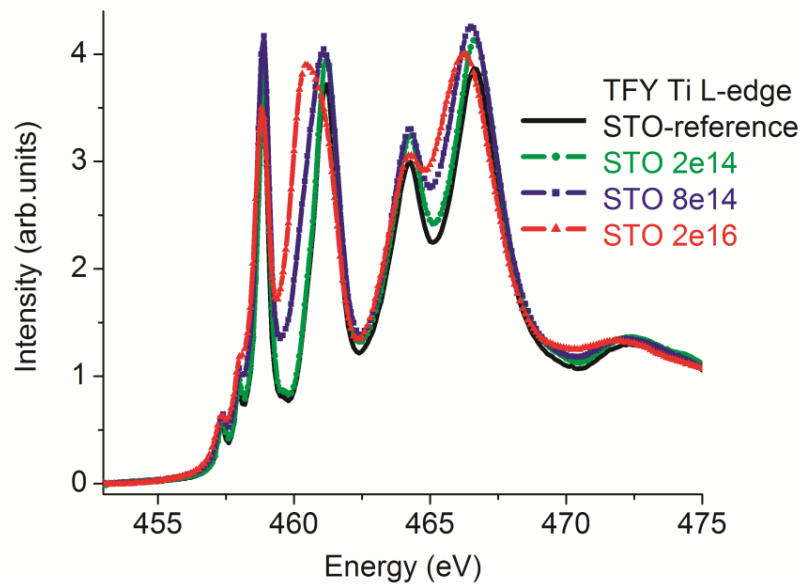
Implanted doses:  
 $2 \times 10^{14}$ ,  $8 \times 10^{14}$  and  $2 \times 10^{16}$  atoms/cm<sup>2</sup>



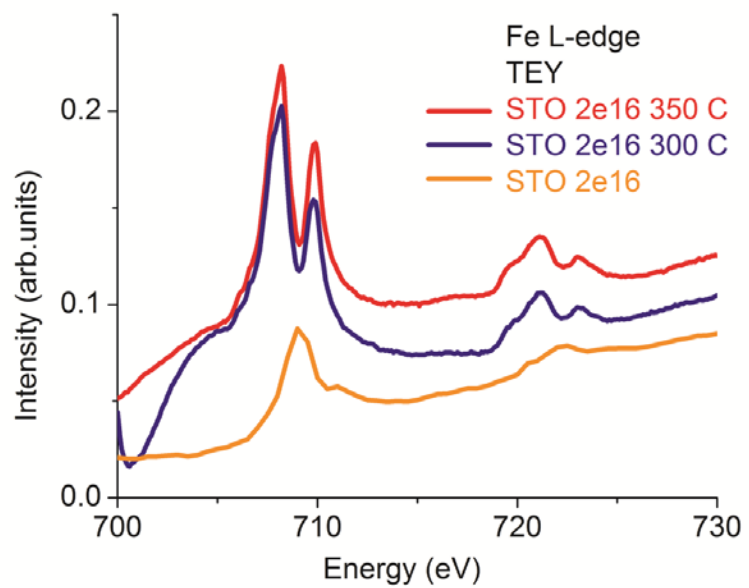
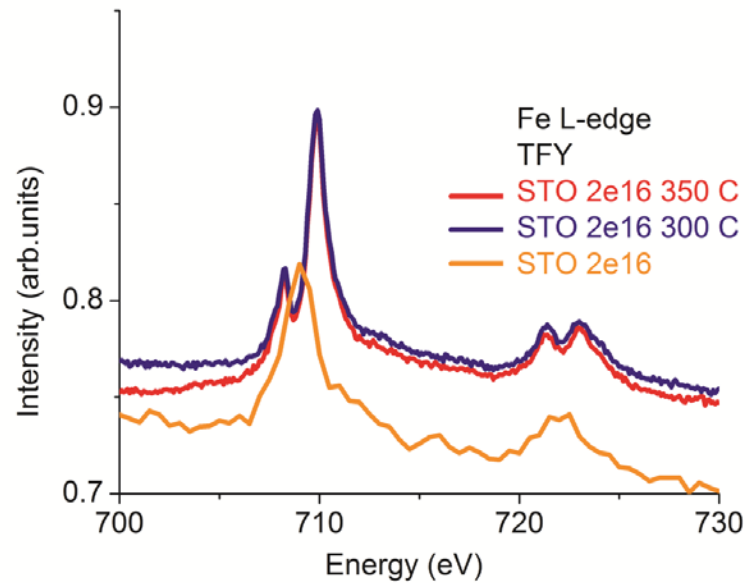
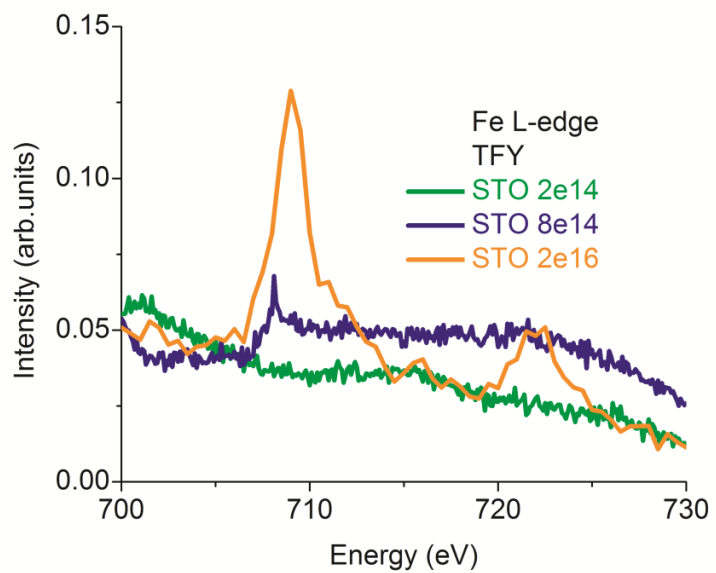


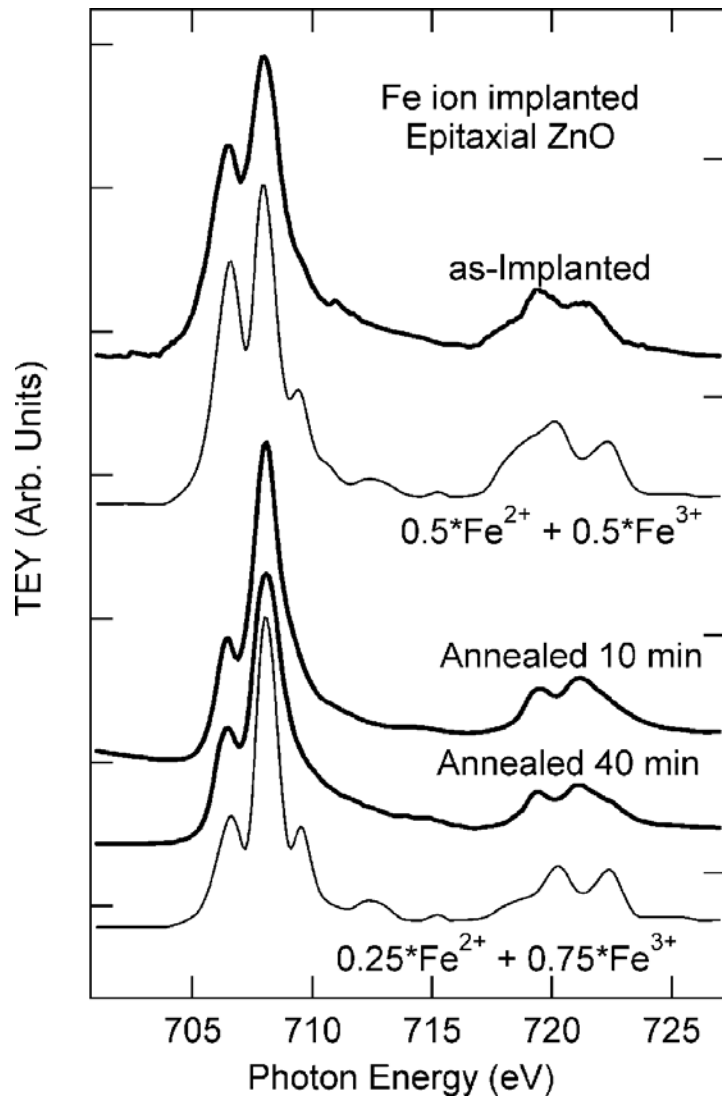




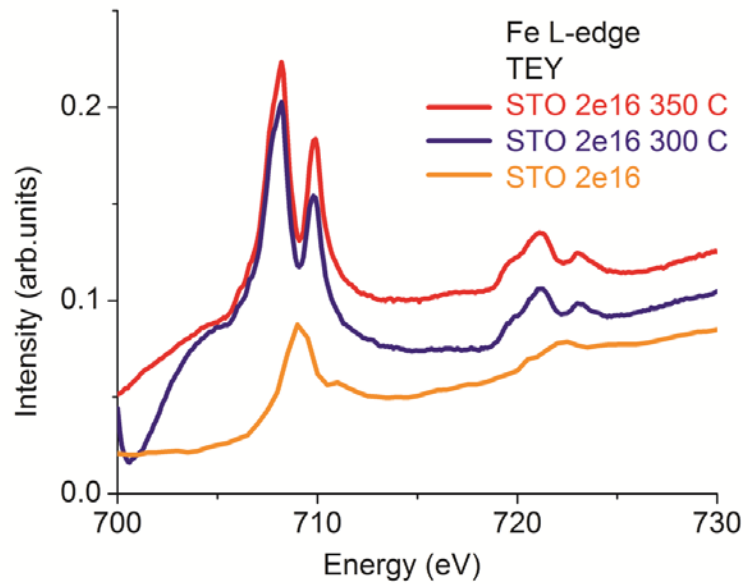
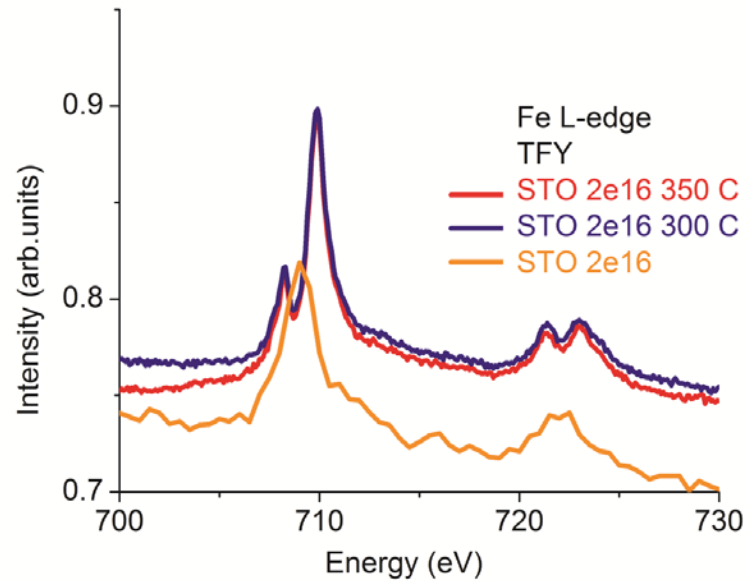
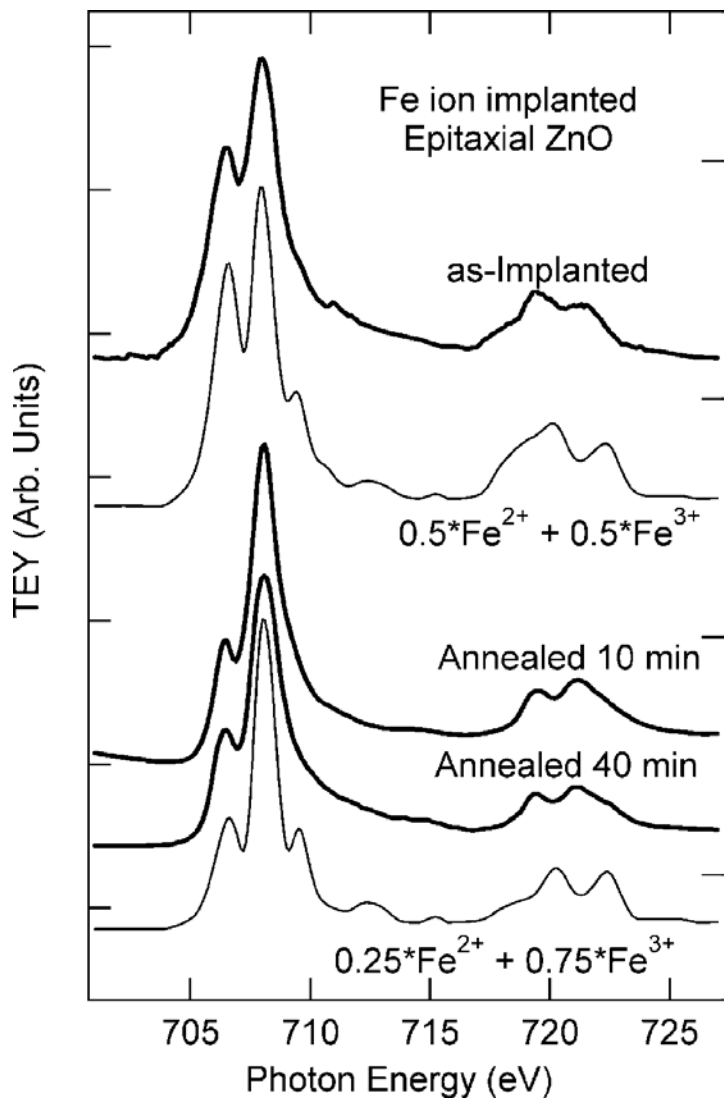


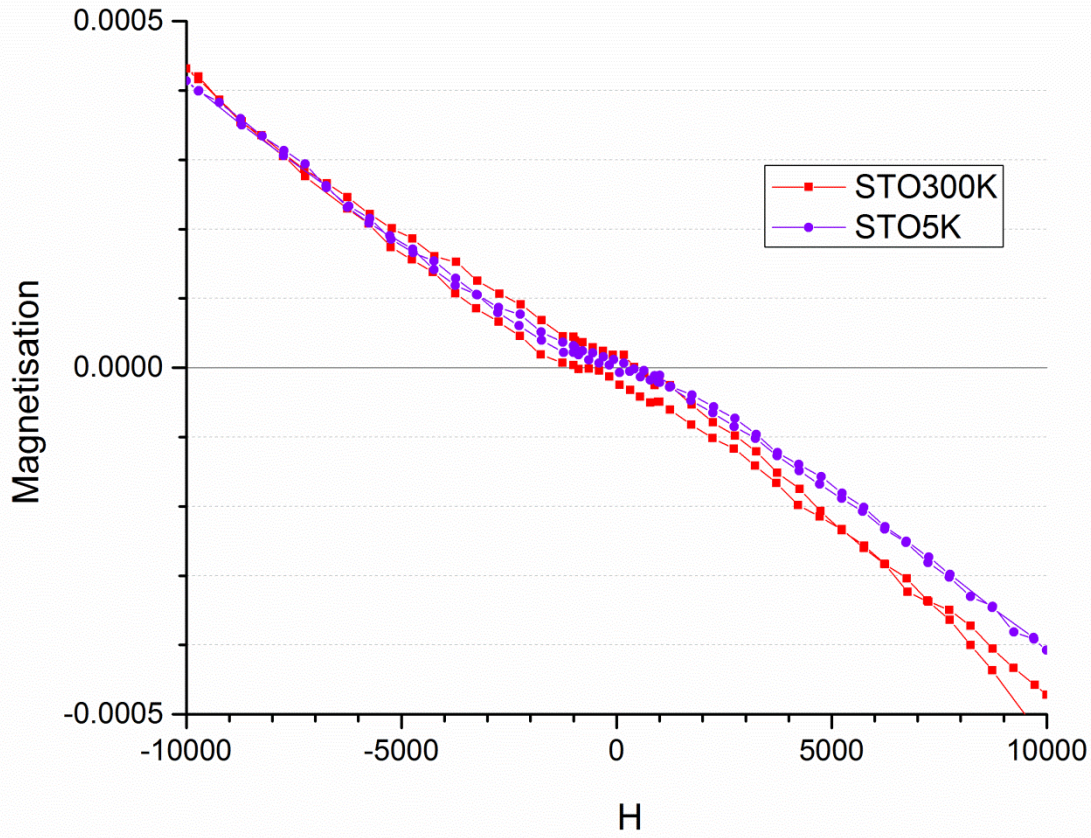


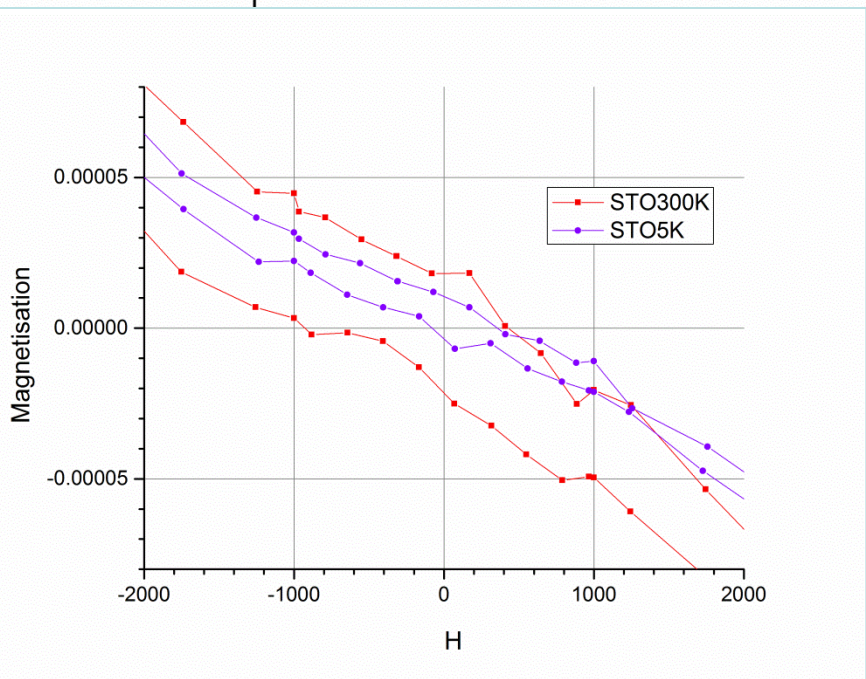
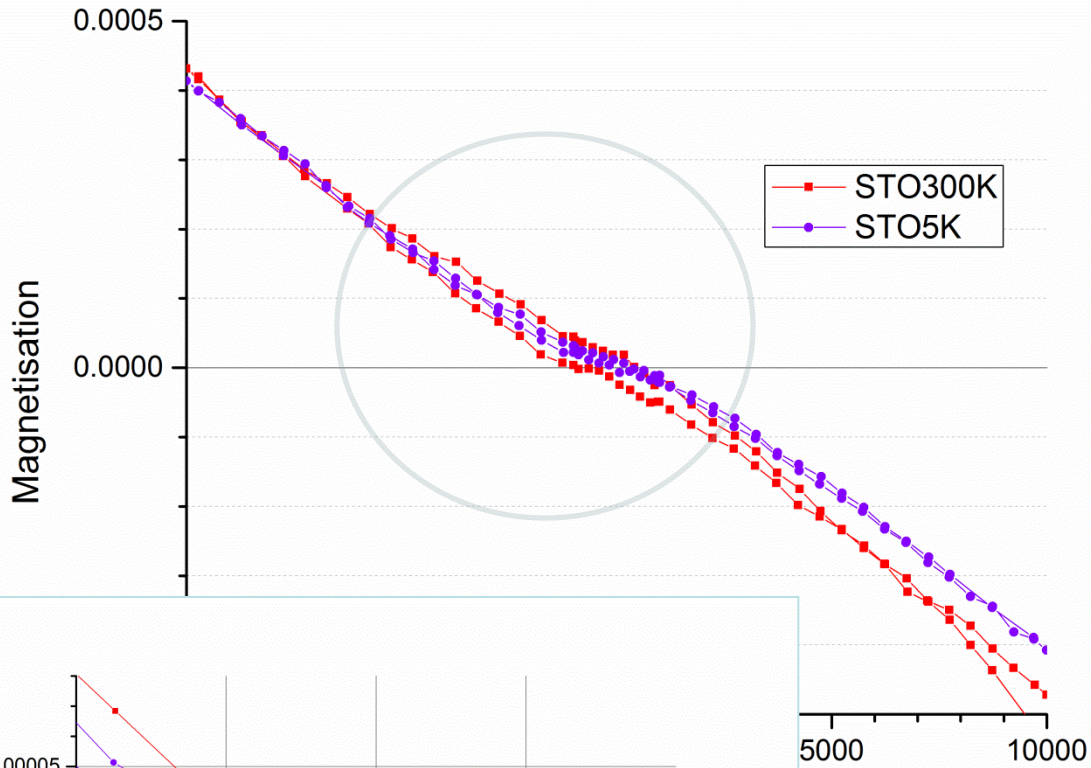


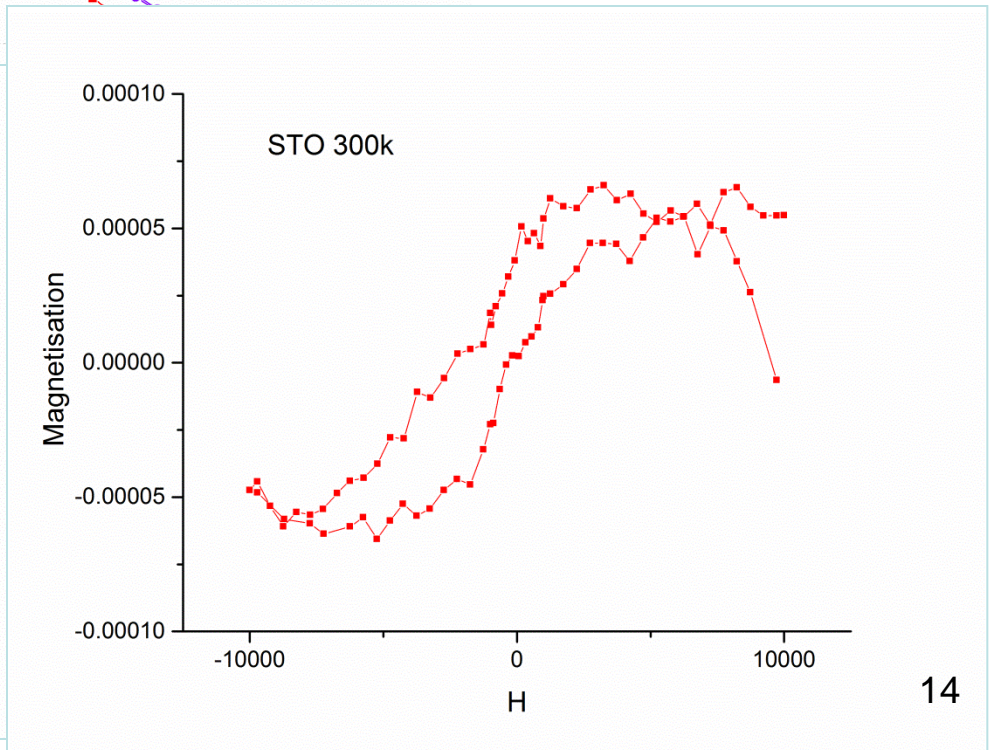
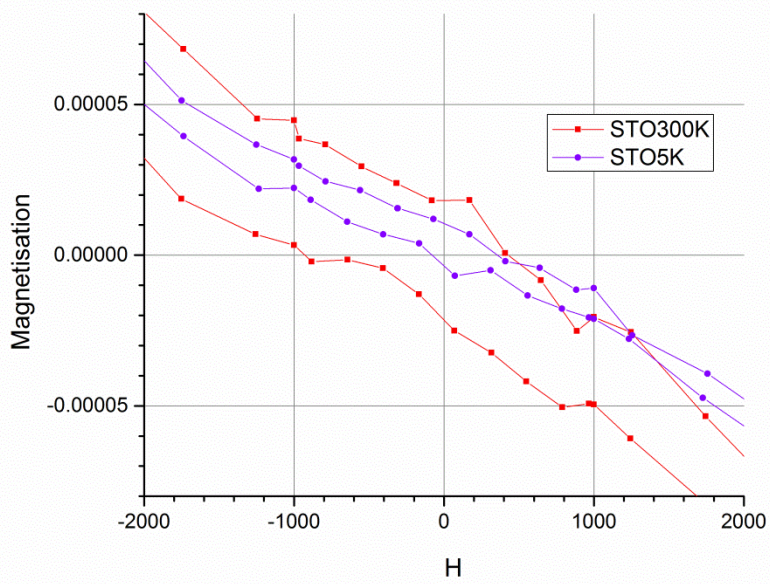
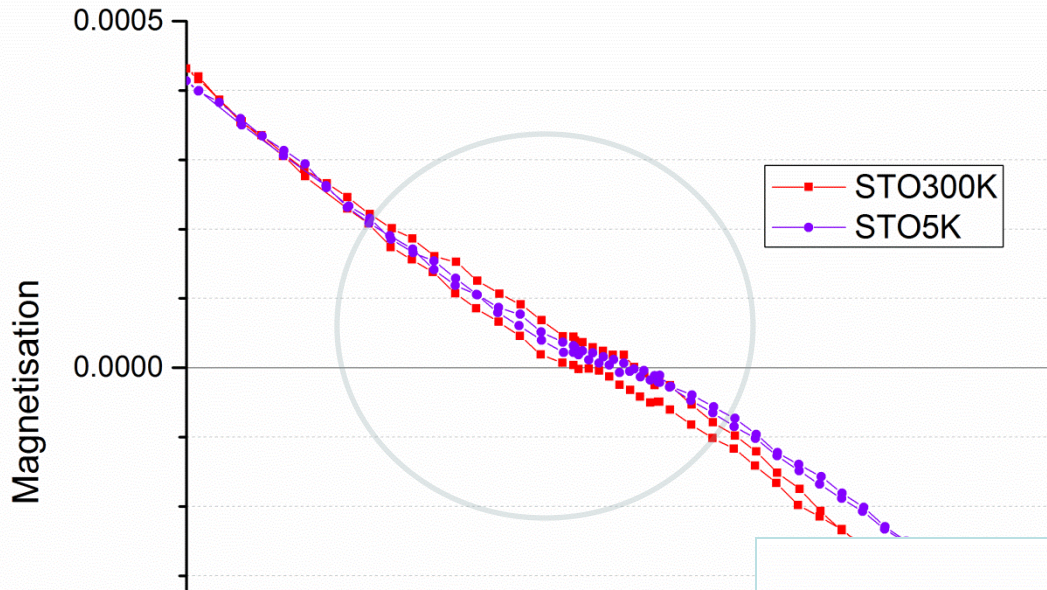


- Fe ions of dose  $5 \times 10^{16} \text{ cm}^{-2}$  were implanted at 200 keV into  $\alpha$ -plane ZnO epitaxial films
- annealing at 700 °C









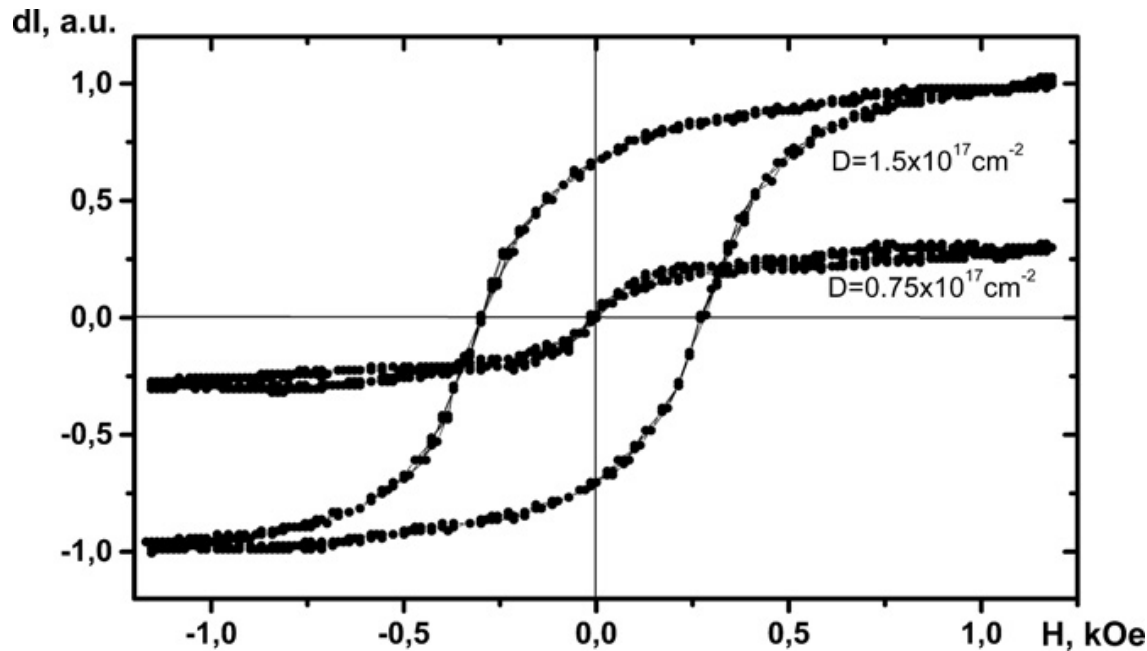
## **Conclusions:**

- **Iron ion implantation produces irradiation damage of STO crystal**
- **Post-implantation annealing partially heals irradiation damage**
- **Magnetization measurement on STO samples (virgin and implanted) showed predominately diamagnetic response (typical to clean strontium titanate)**
- **Ferromagnetic contribution of Fe ions and oxygen defects requires further investigation**

**Thank you !**



## Magnetic phase composition of strontium titanate implanted with iron ions



(1 0 0)-oriented single crystalline plates of STO with 40 keV iron ions

Iron substitute  $\text{Ti}^{4+}$  ions by  $\text{Fe}^{2+}$  or  $\text{Fe}^{3+}$

75% of implanted iron --  $\alpha$ -Fe

nanoparticles – 5nm, randomly oriented

STO  $0.75 \times 10^{17} \text{ cm}^{-2}$  -- predominance of  $\text{Fe}^{2+}$  -- superparamagnetic

STO  $1.5 \times 10^{17} \text{ cm}^{-2}$  -- predominance of  $\text{Fe}^{3+}$  -- ferromagnetic

