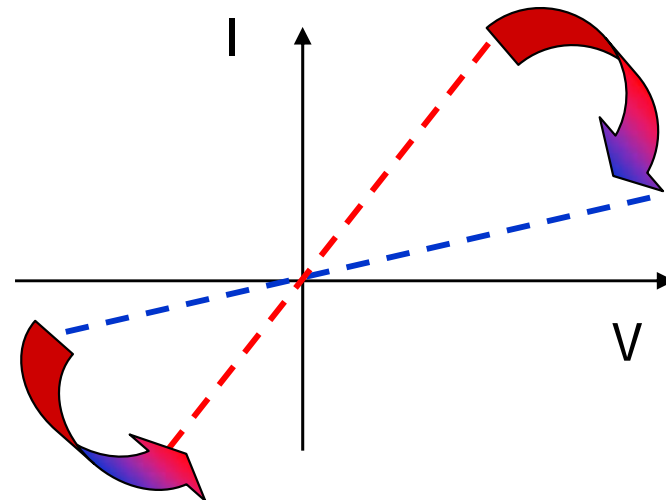
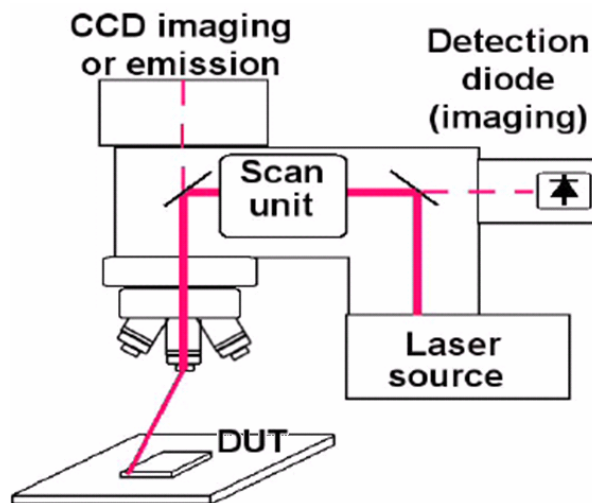


Optical investigation of a resistance-change memory device

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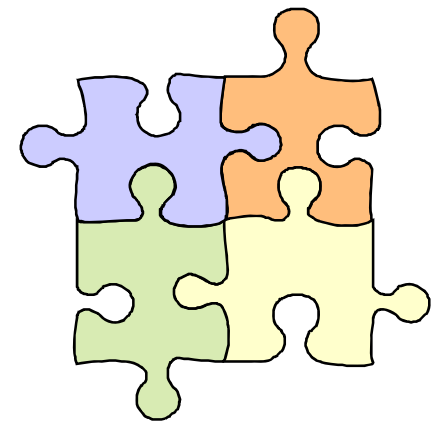
Outline

Resistance-change memory

Cr-doped SrTiO₃ single crystal

**Emission spectroscopy :
IR-NIR microscope, electro-luminescence**

**Optical beam induced resistance change
(OBIRCH)**

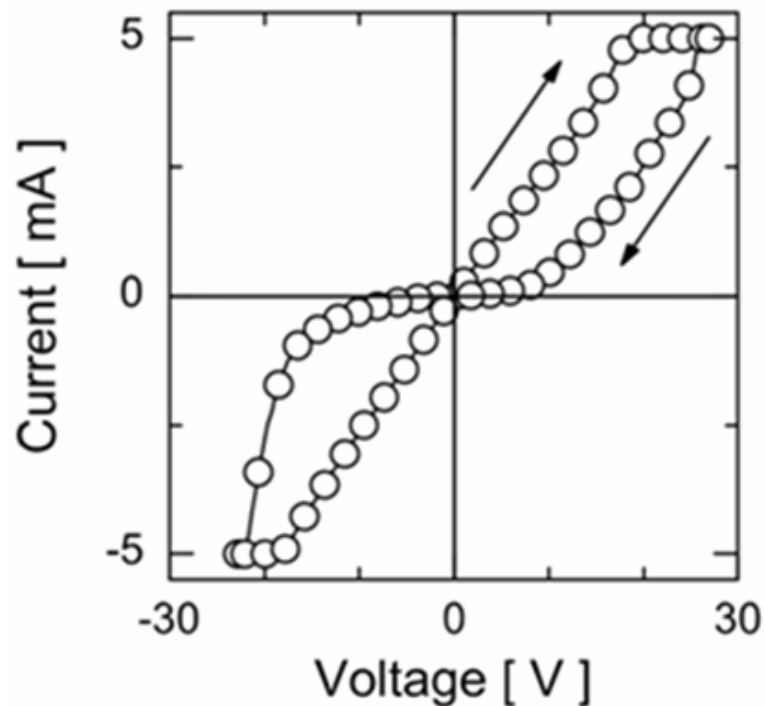


Non-volatile memory devices

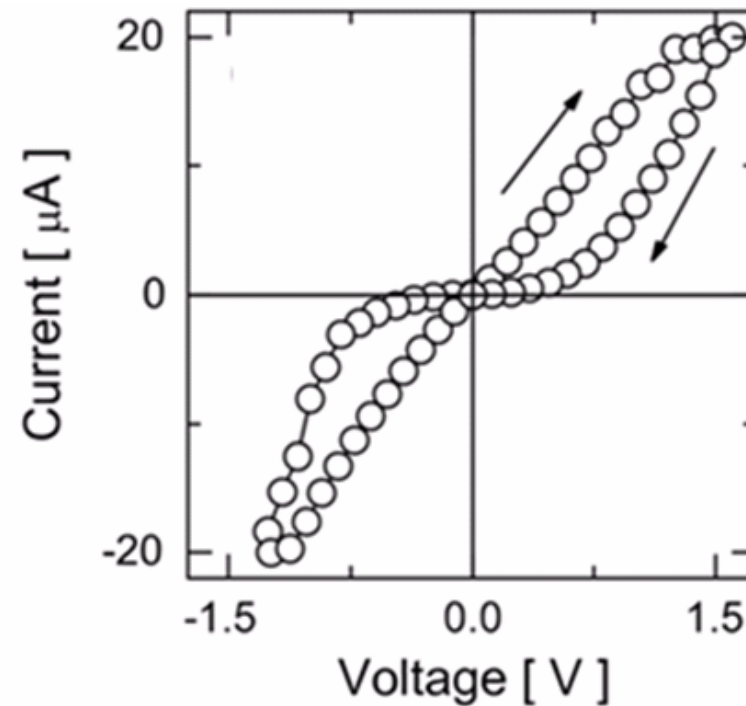
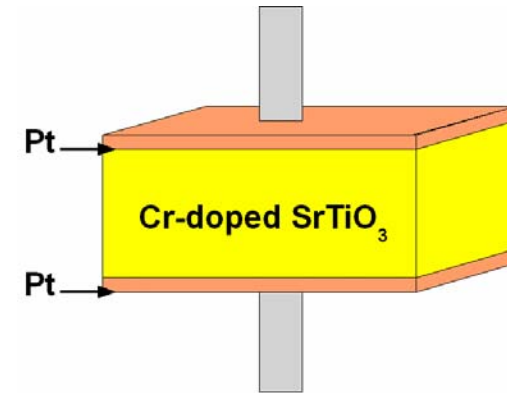
Planar structure



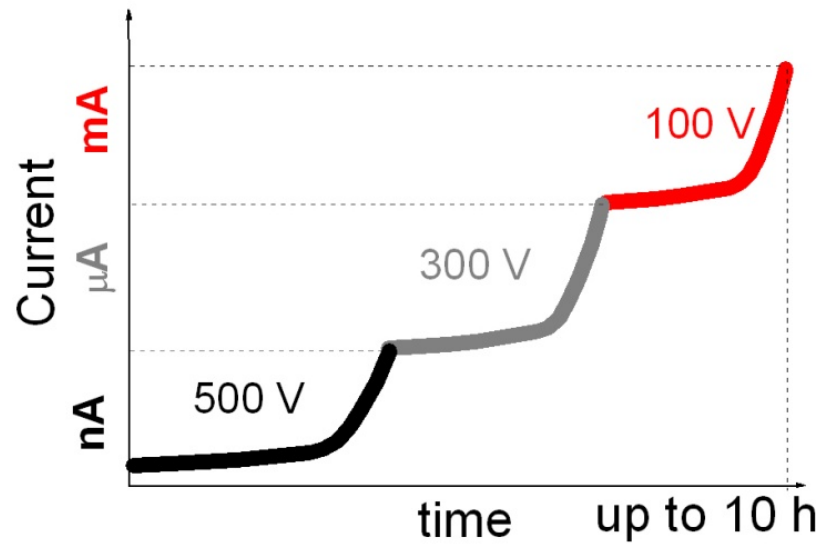
Resistance-change device



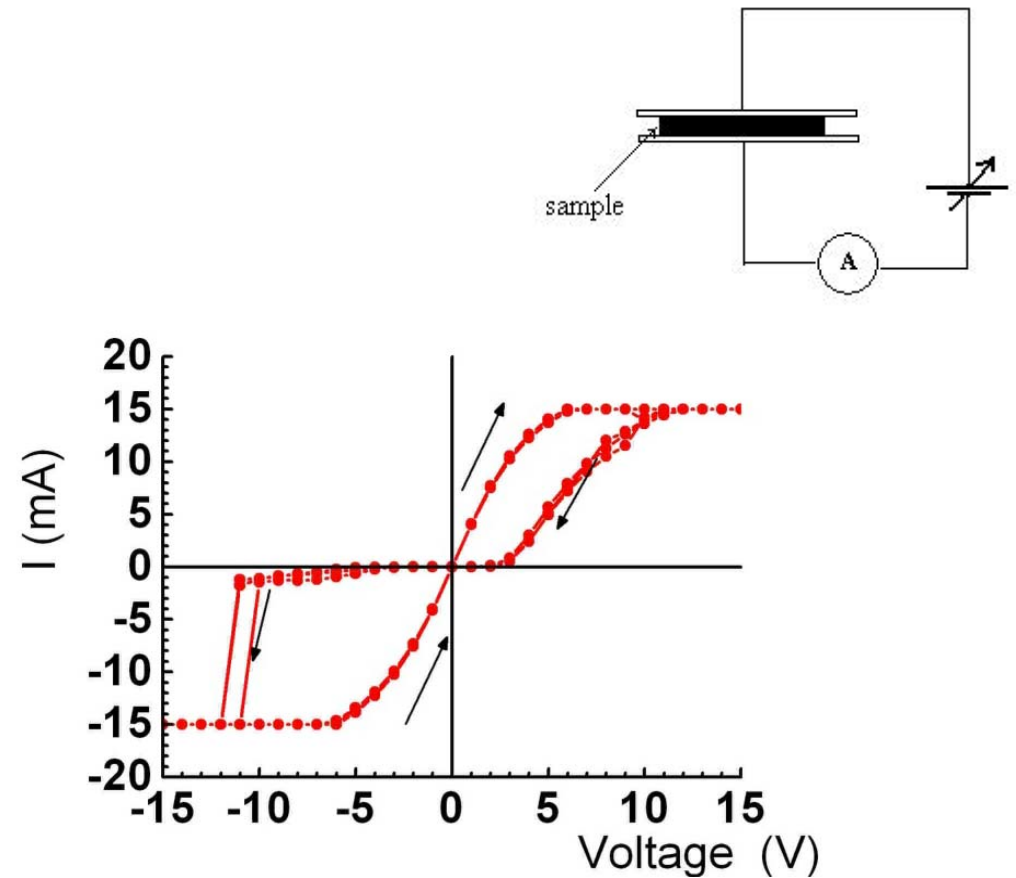
Capacitor-like structure



Electric Field effects on Cr-doped SrTiO₃



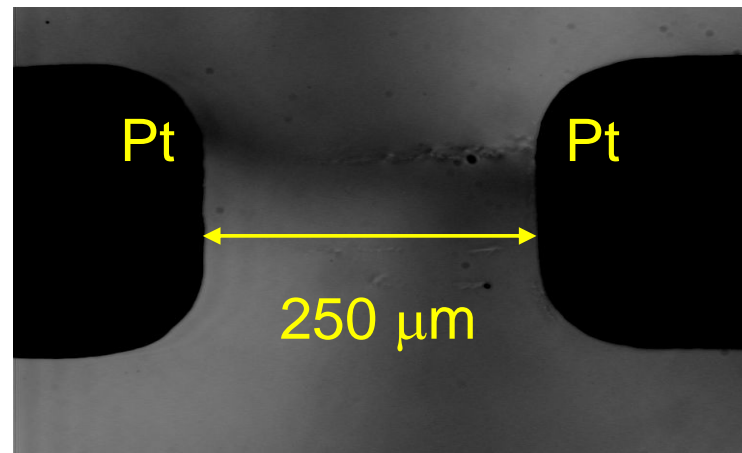
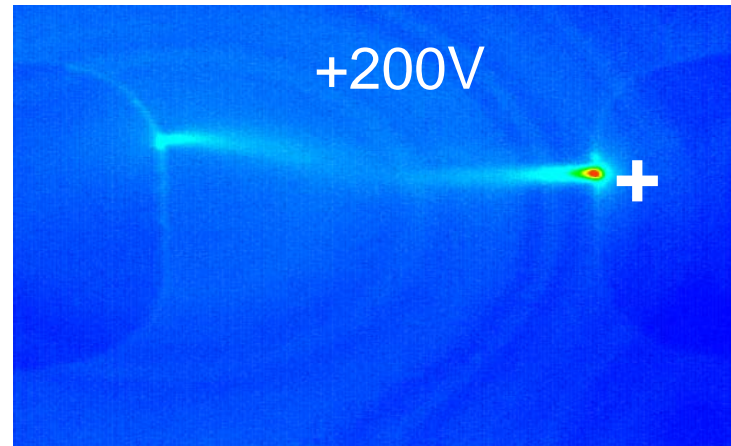
Electro-Conditioning



Resistive Switching

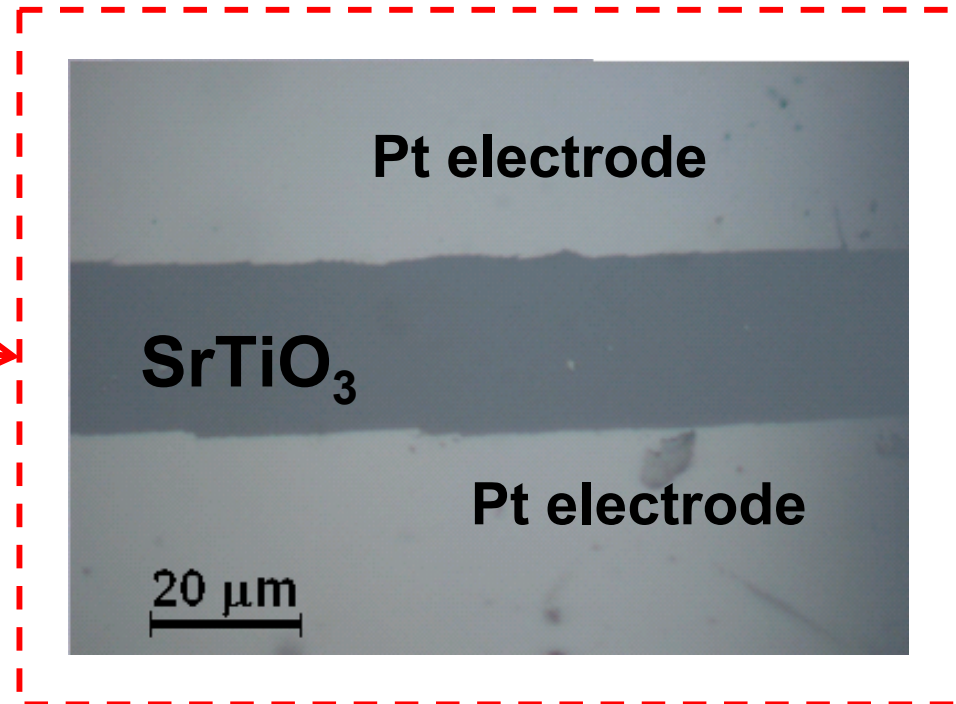
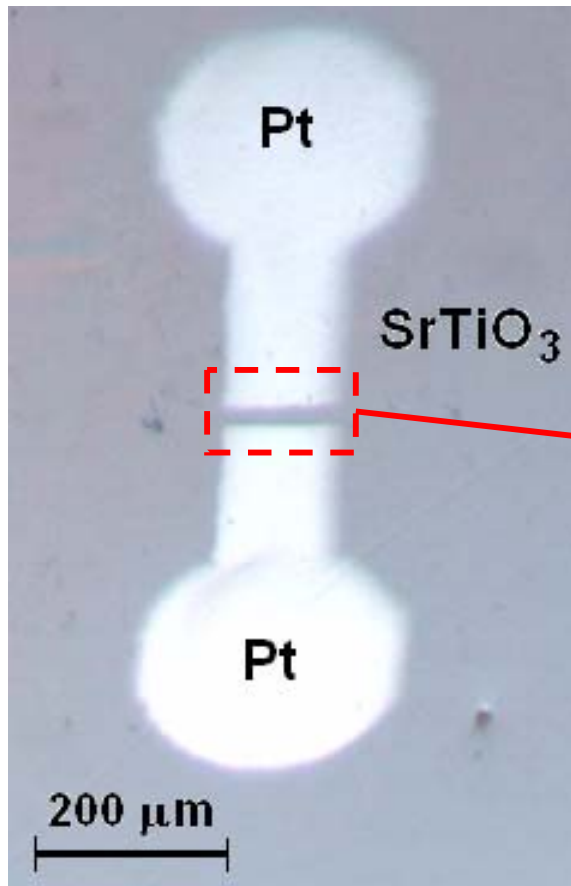
Electronic properties changed in confined regions

IR
microscope
→



←
Polarized
light

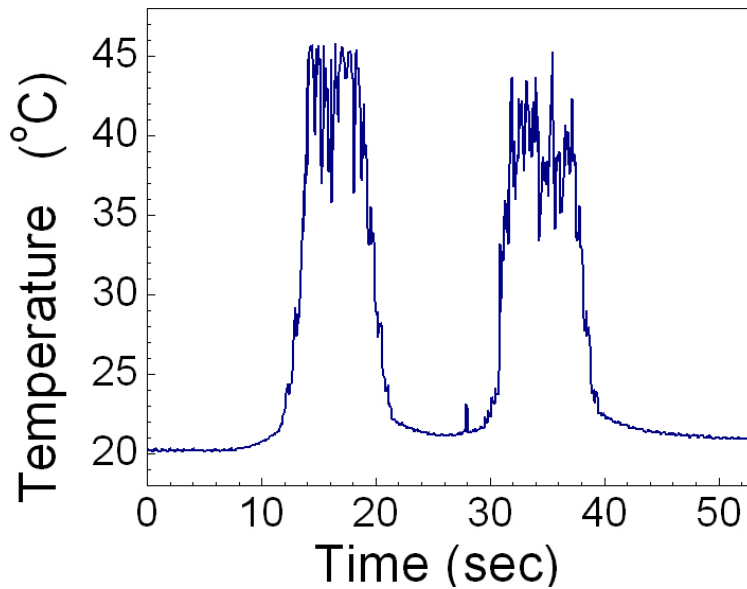
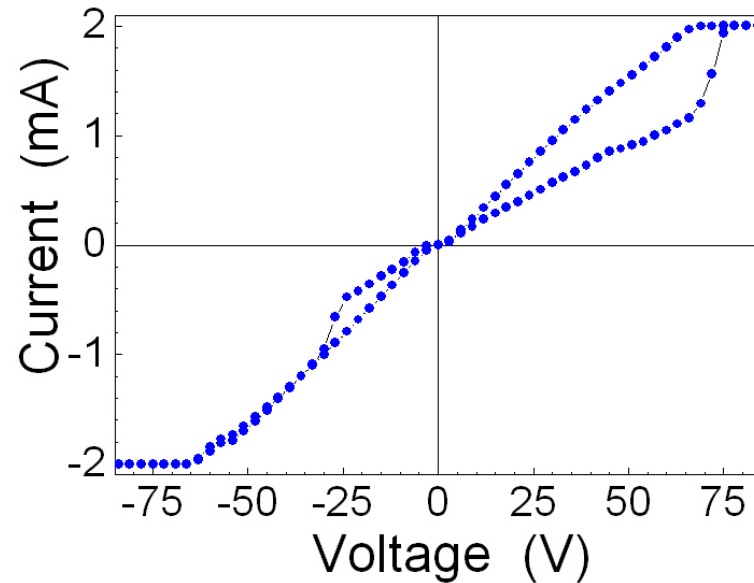
Planar electrodes



$$E_{\text{threshold}} > 10^4 \text{ V/cm} \rightarrow \text{EC Process}$$
$$\text{Gap} \sim 24 \mu\text{m} \rightarrow E_{\text{threshold}} \sim 100 \text{ V}$$

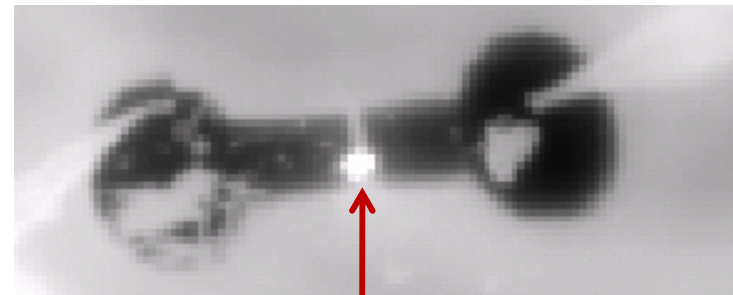
La Mattina et al., Appl. Phys. Lett. **93**, 022102 (2008)

IR microscope



Spectral range = 3 to 5 μm

Imaging of the IR light emission



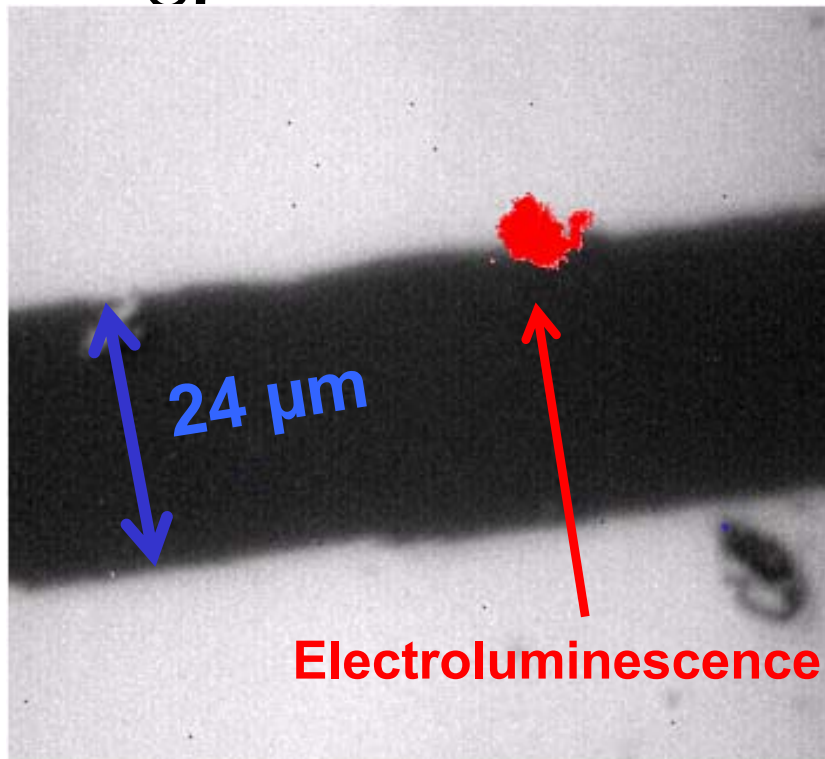
(2 mA and 75 V)

Thermal emission

$T_{\text{max}} < 45$
 $^{\circ}\text{C}$

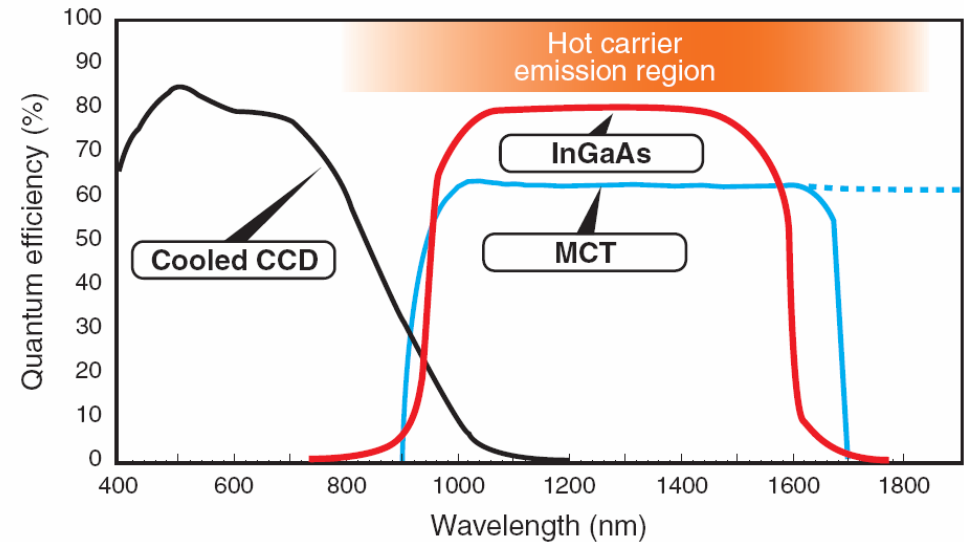
Near Infrared (NIR) emission

$T_{\max} < 45$
°C



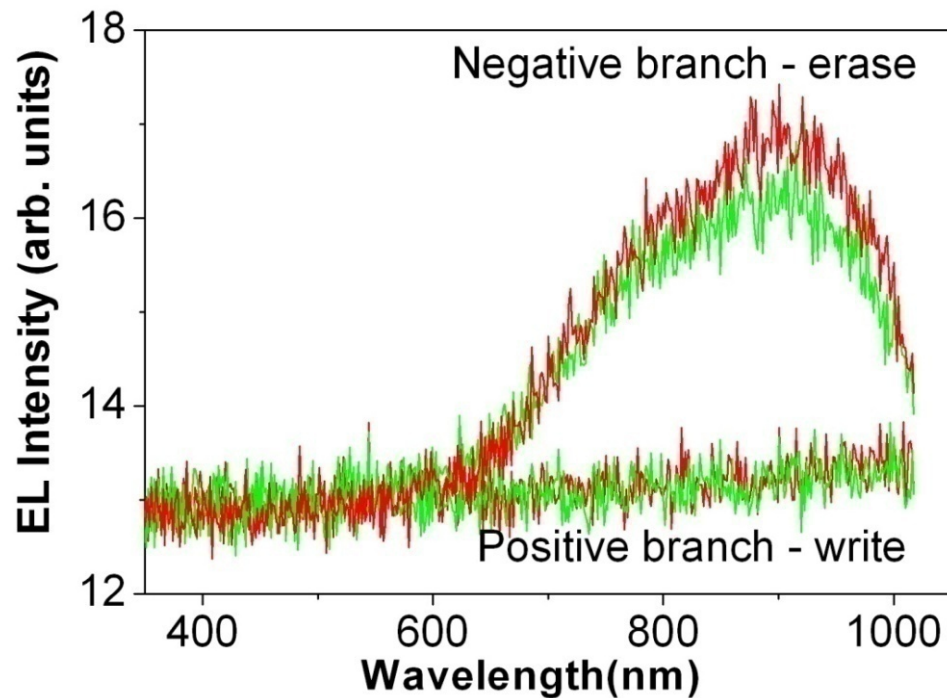
source = 25 V

A comparative chart of wavelength sensitivity ranges



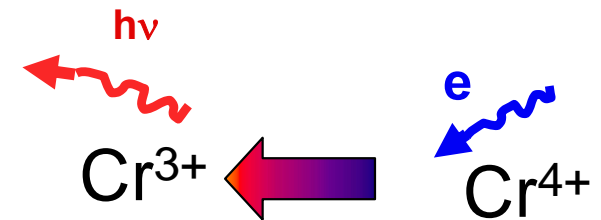
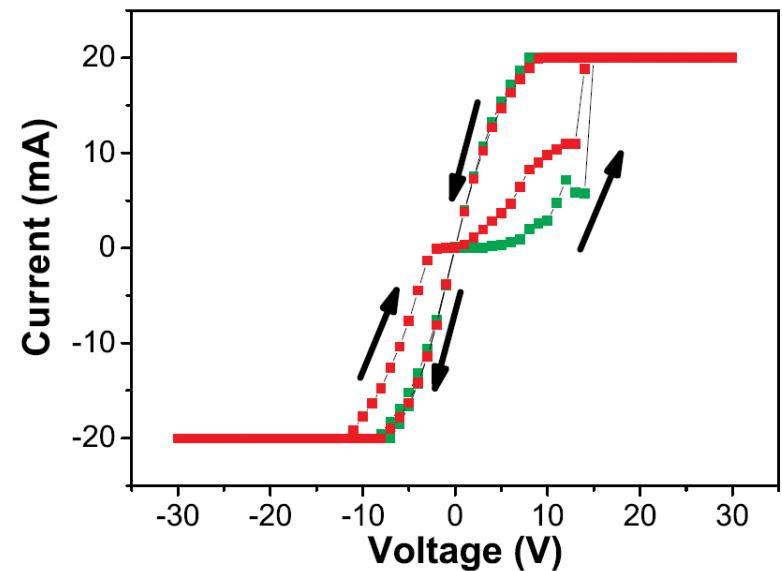
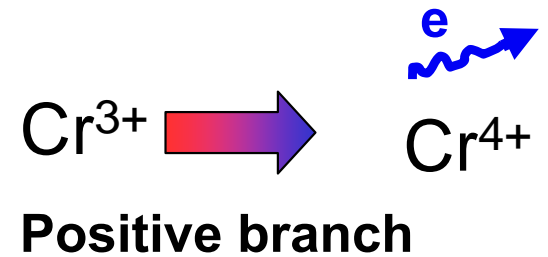
InGaAs Camera (Hamamatsu)
nitrogen cooled
Spectral range = 900 to 1600 nm

Electroluminescence (EL): Charge transfer processes during the resistance switching



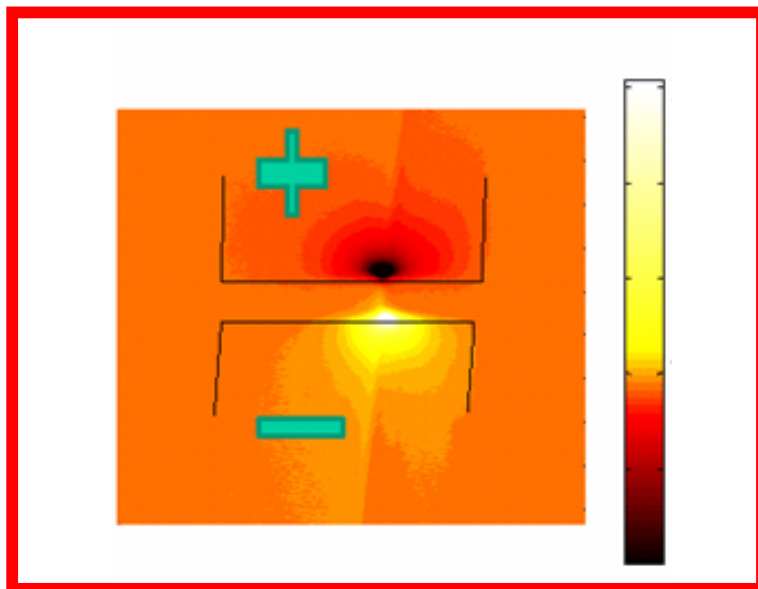
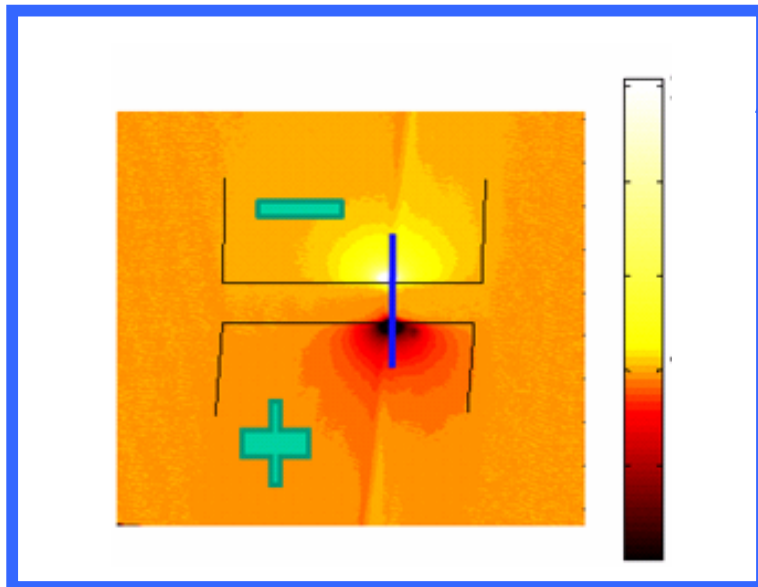
Alvarado et al., Appl. Phys. A **89**, 85 (2007)

La Mattina et al., Appl. Phys. Lett. **93**, 022102 (2008)

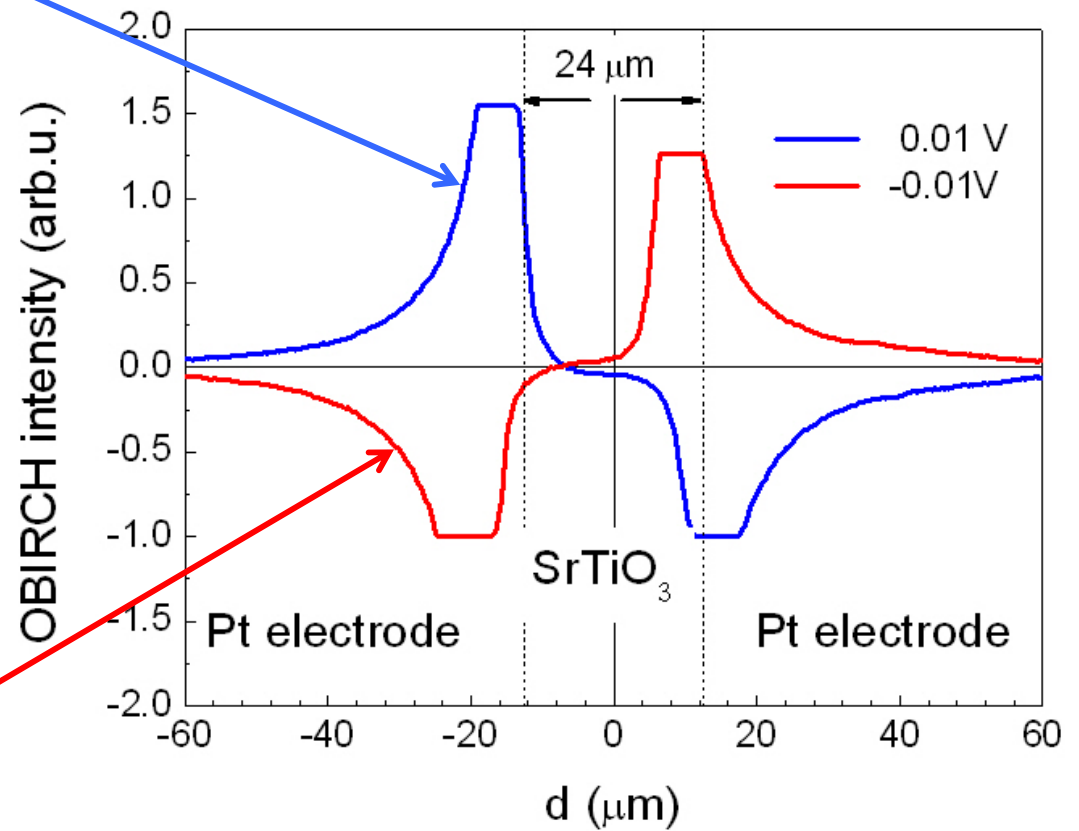


**Negative branch
light emission**

Imaging of the OBIRCH signal



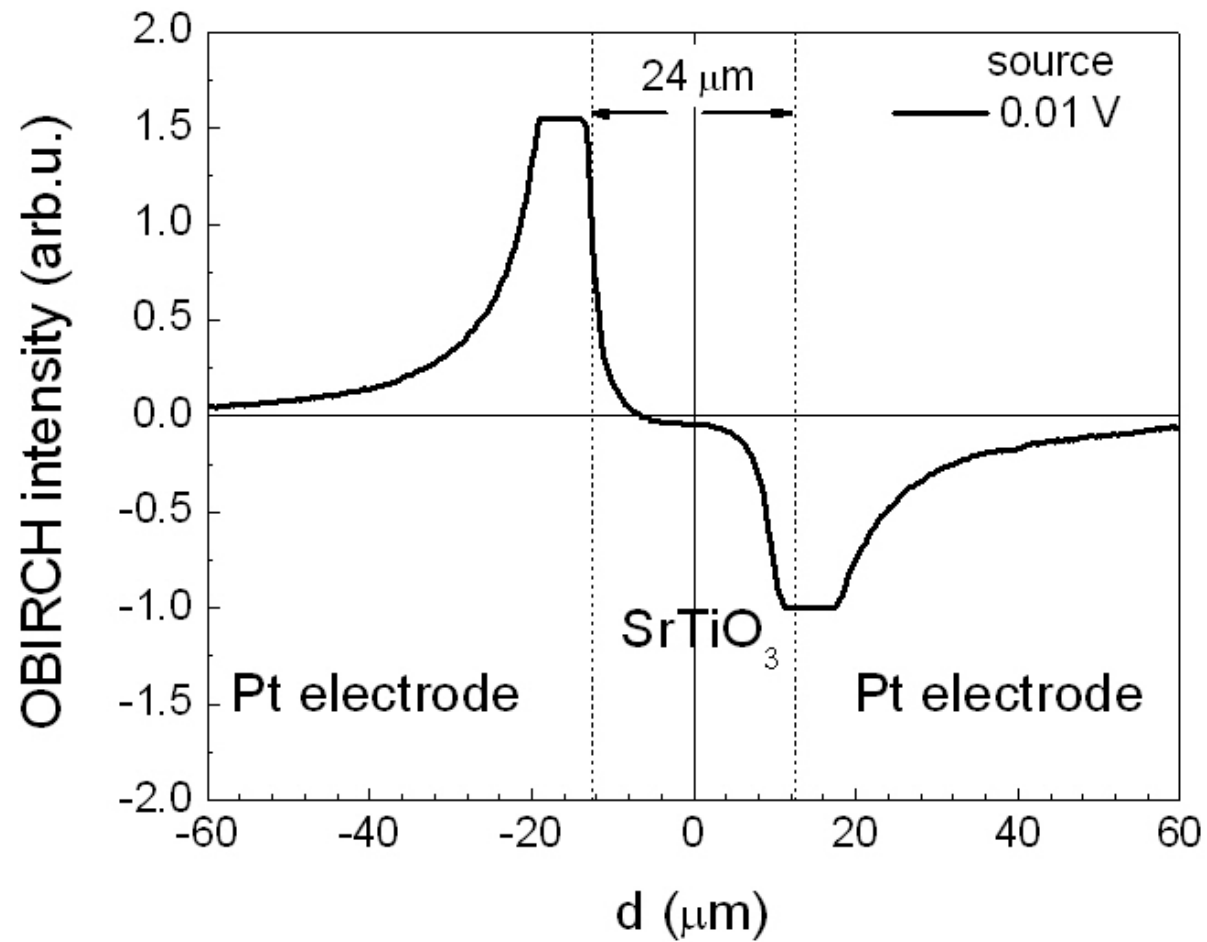
$$\Delta\rho = \rho_0 \times K \times (T - T_0)$$



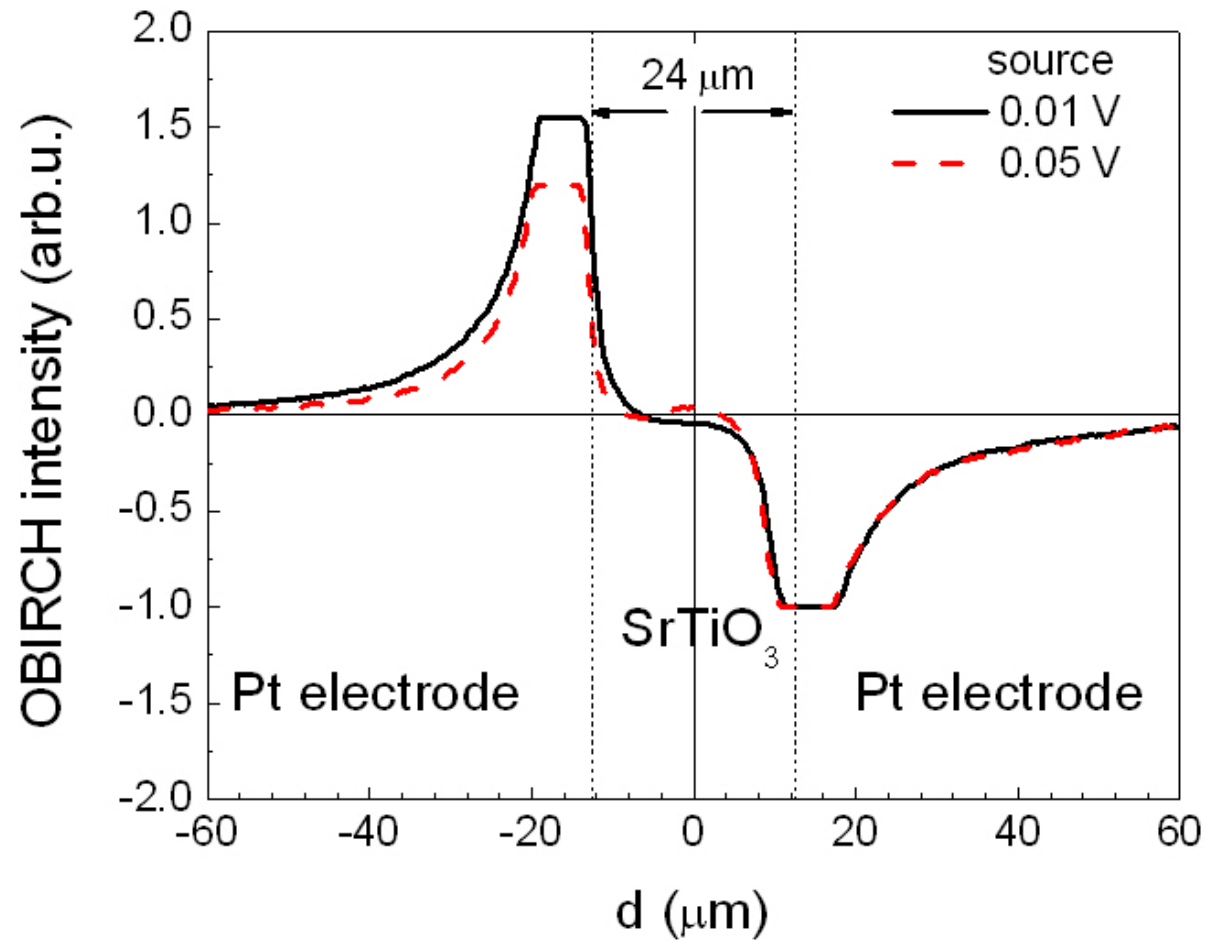
Source = 0.01V

Wavelength = 1.3 μm

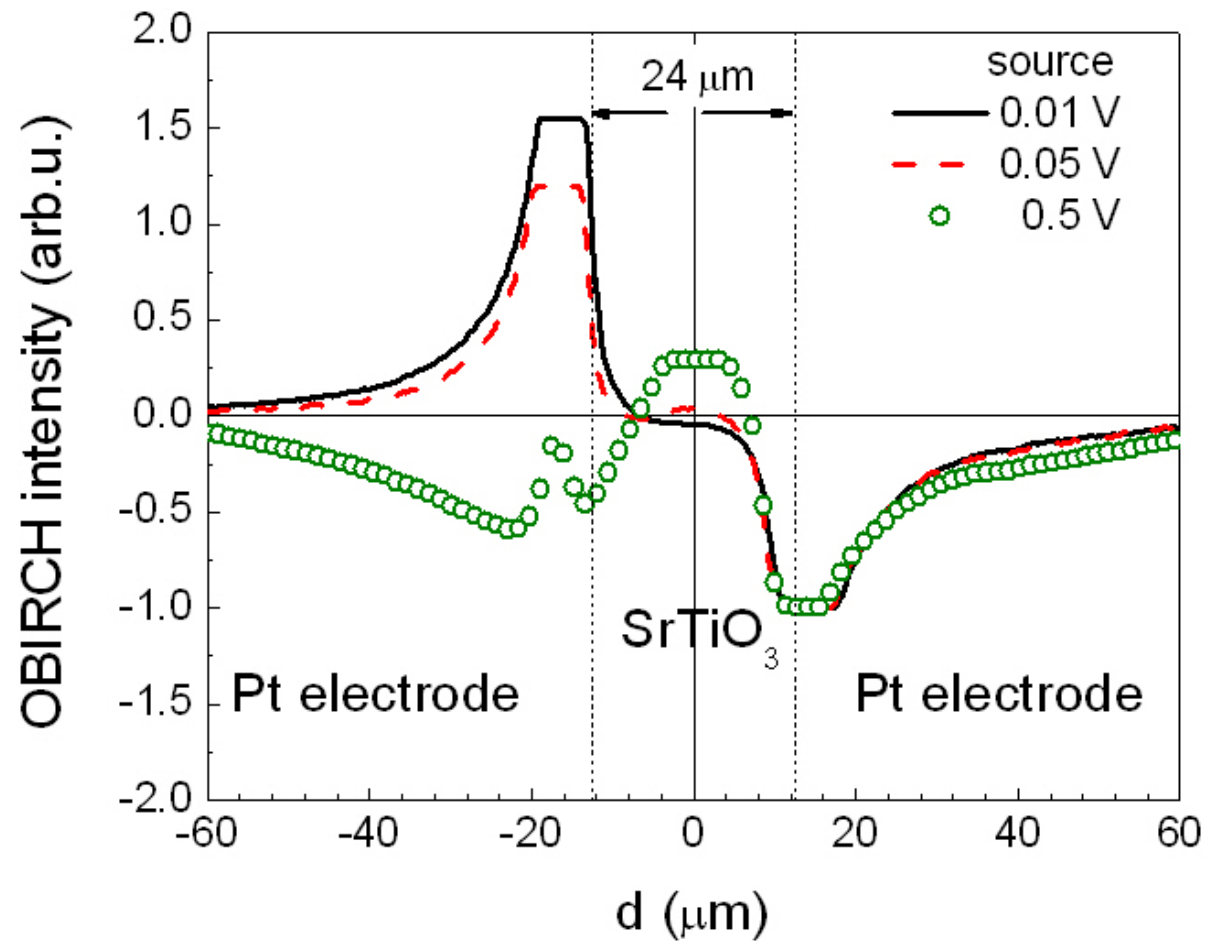
Pt/SrTiO₃/Pt interfaces



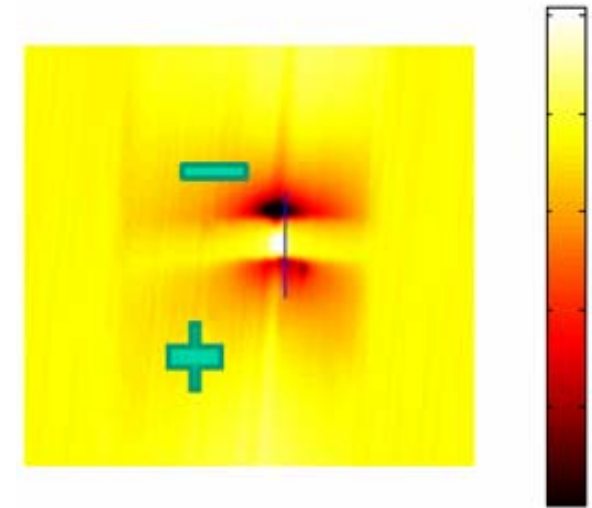
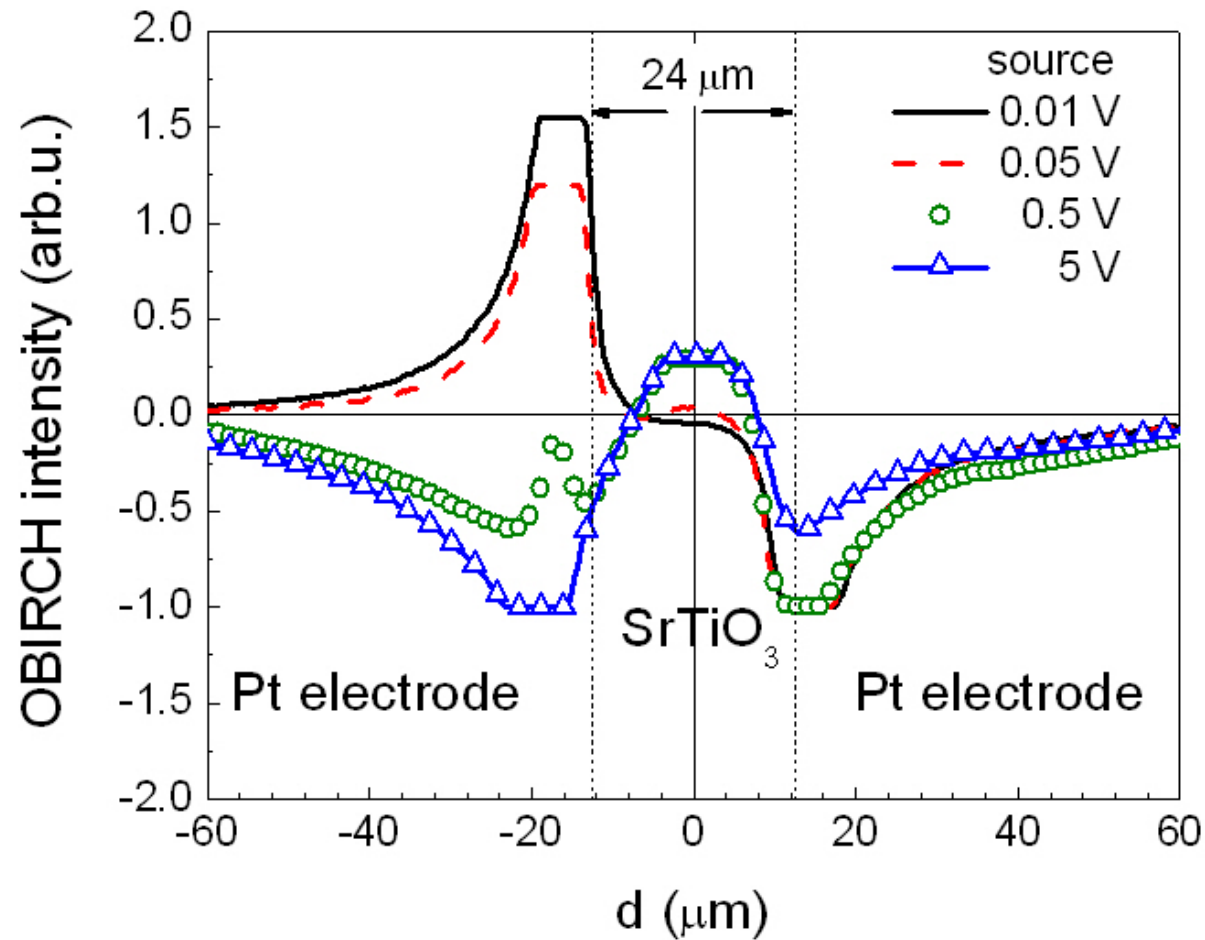
Pt/SrTiO₃/Pt interfaces



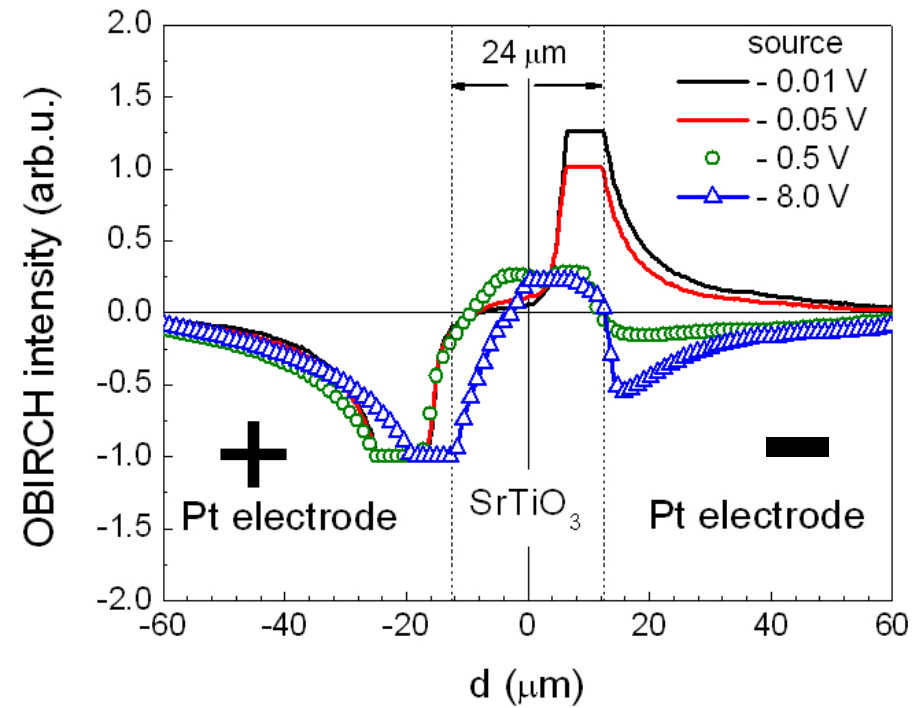
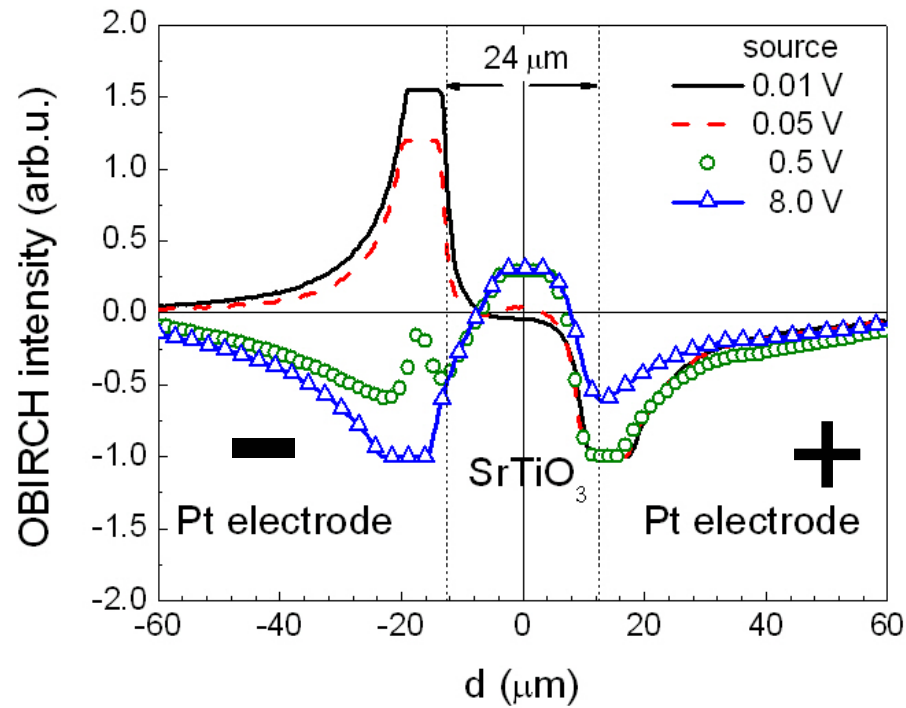
Pt/SrTiO₃/Pt interfaces




Pt/SrTiO₃/Pt interfaces



Pt/SrTiO₃/Pt interfaces



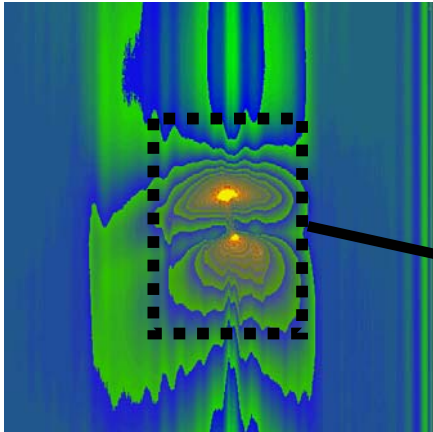
|Source| > 0.5 V 

Metallic behavior of the Pt/SrTiO₃ interfaces

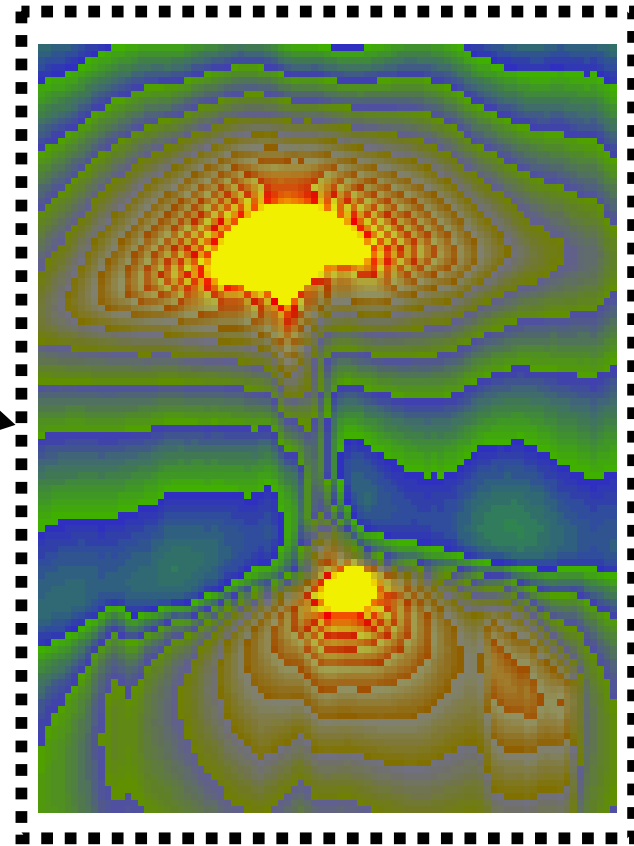
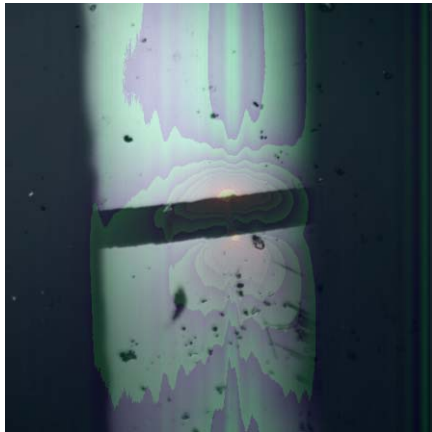
“Bulk” SrTiO₃ semiconducting behavior.

The conducting path

OBIRCH signal



Superimposed signal



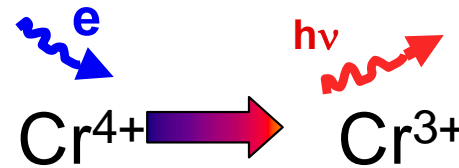
How does the heat diffusion influence the OBIRCH signal?

Summary

EL, IR and NIR microscope

Small heating effect during IV loop.

By means of the NIR microscope we could do imaging of the EL



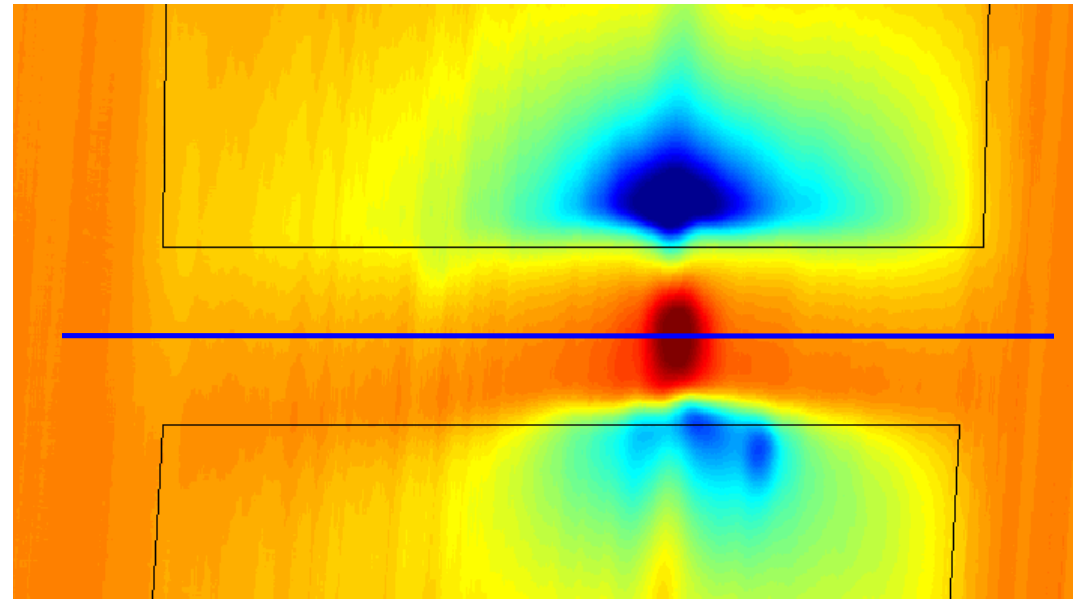
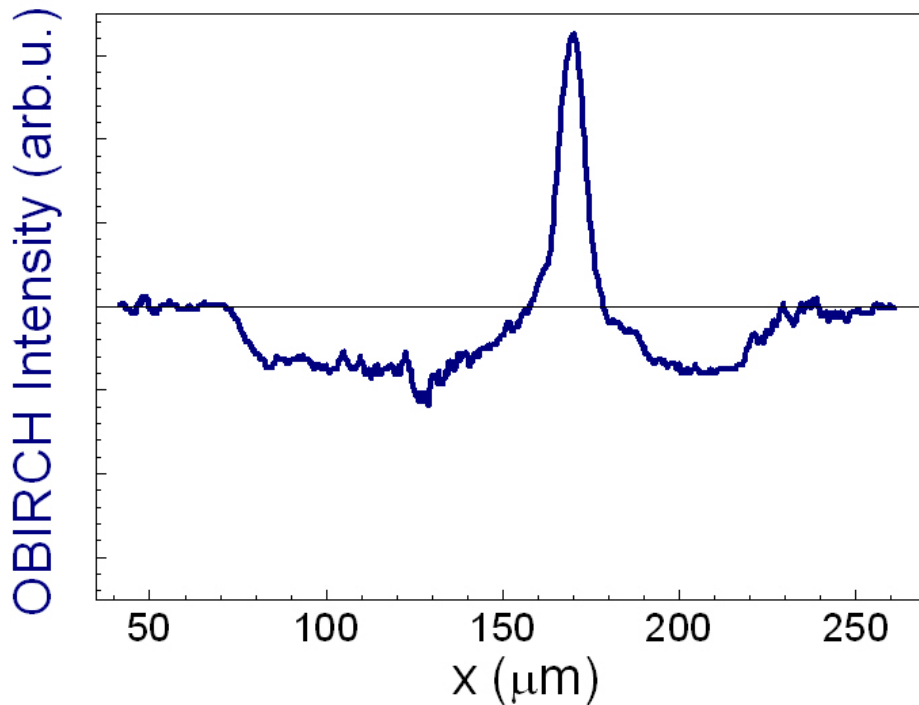
OBIRCH

Inhomogeneities of the conductivity

A Schottky barriers are present at the Pt/SrTiO₃ interfaces and dominate the conducting behavior at low voltage.

Interpretation of the OBIRCH signal

$$\Delta\rho = \rho_0 \times K \times (T - T_0)$$



thermal effects, heat diffusion, charge transfer, electron-hole pair generation



Interpretation of the signal:
metallic behavior
semiconductor
Schottky barrier