Manganiti s uređenjem naboja: ac i dc transportna svojstva

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Fizički odsjek, PMF, Zagreb

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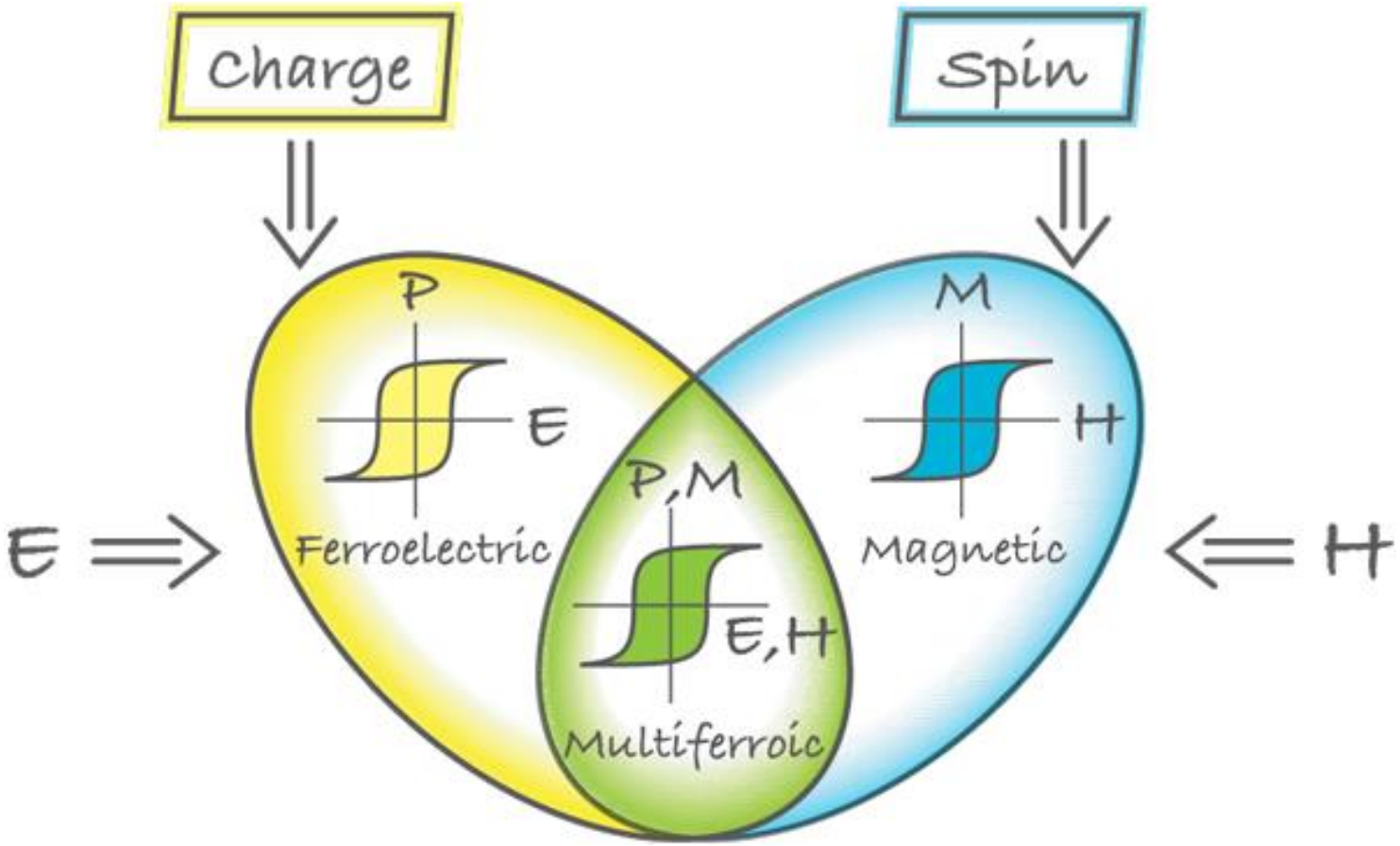
27. siječanj 2017.

Feroici i multiferoici



https://physics.aps.org/articles/v2/20

Manganiti

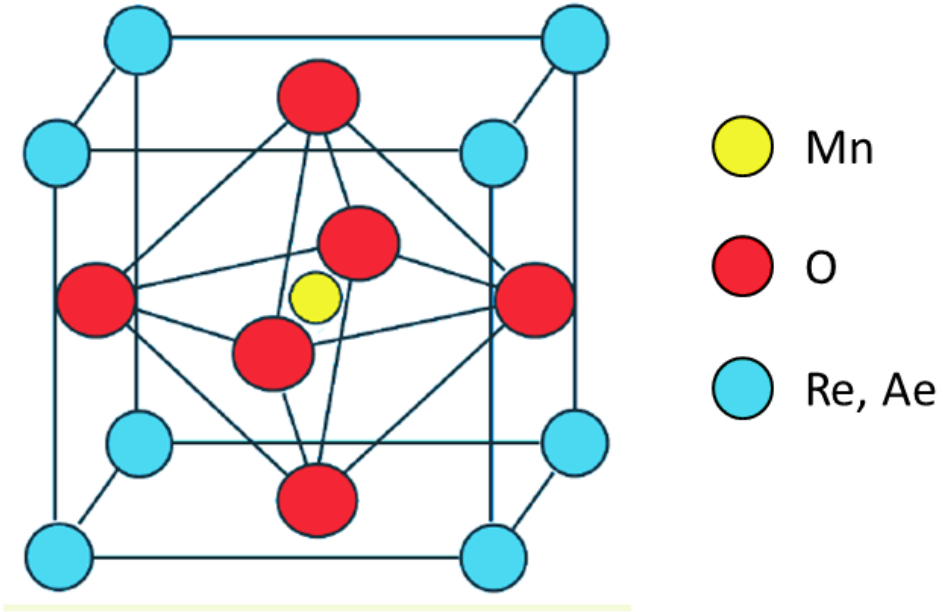
$$\mathrm{Re}^{3+}_{1-x}\mathrm{Ae}^{2+}_{x}\mathrm{MnO}_3$$

rijetki zemni metal

zemnoalkalijski metal

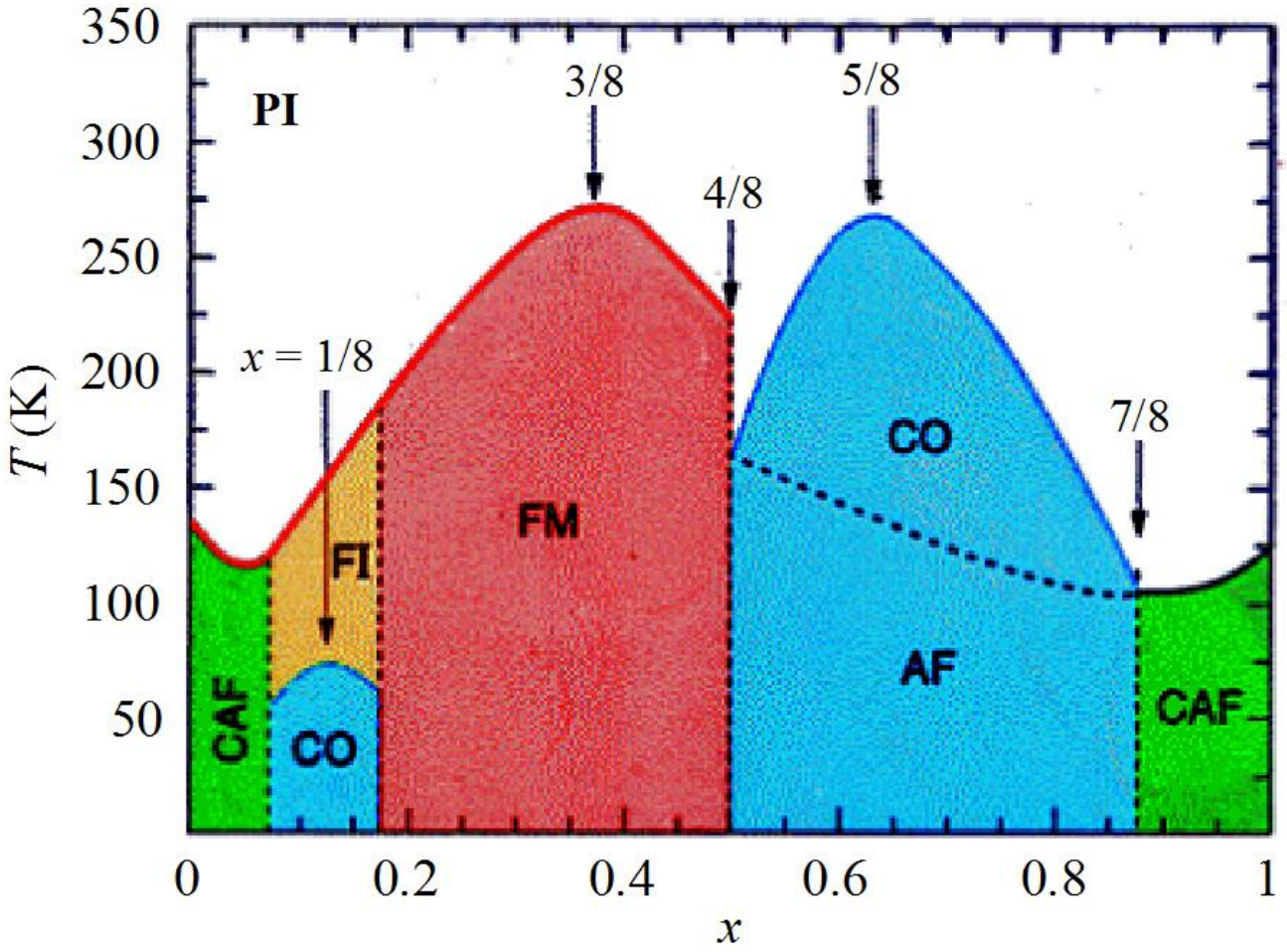
- 1950-e: istovremeno različita uređenja
- 1990-e: kolosalni magnetootpor

perovskitna kristalna struktura



N. Mathur et al. *Physics Today* **56**(1), 25 (2003)

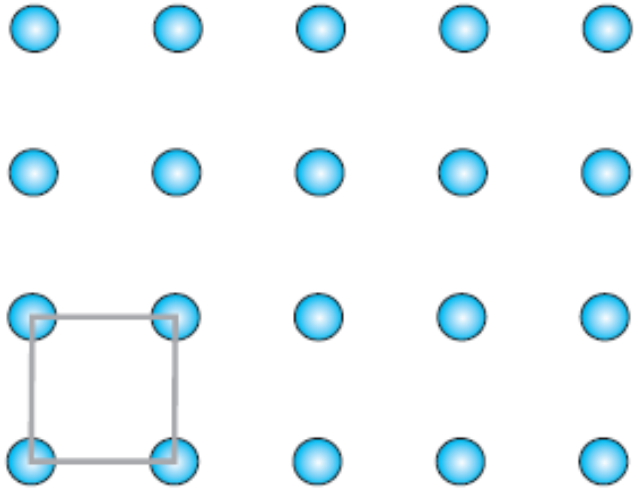
$La_{1-x}Ca_xMnO_3$



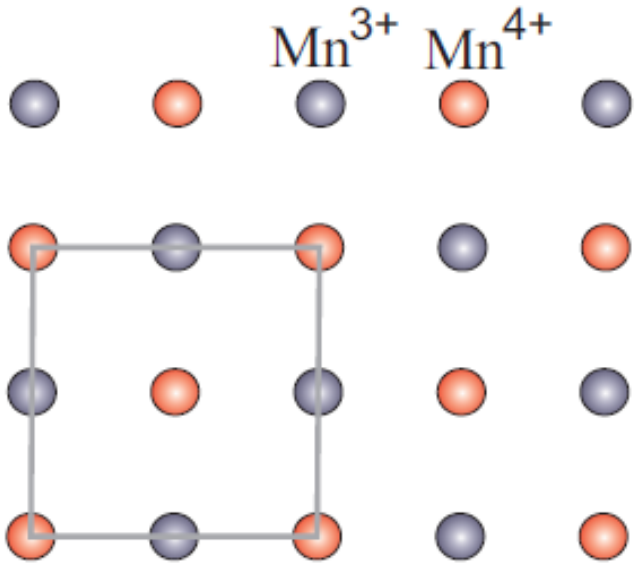
Fazni dijagram

E. Dagotto et al. *Physics Reports* 344 (2001)

Uređenje naboja



nema uređenja naboja

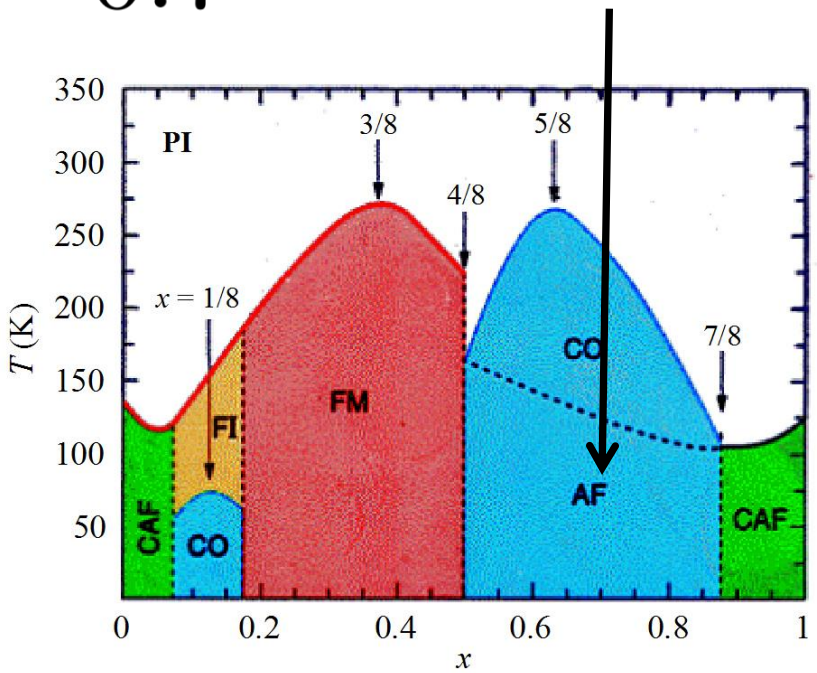


uređenje naboja

J. de Groot (2012). *Charge, spin and orbital order in the candidate multiferroic material* $LuFe_2O_4$ (Doktorska disertacija).

$La_{1-x}Ca_xMnO_3,\ x = 0.7$

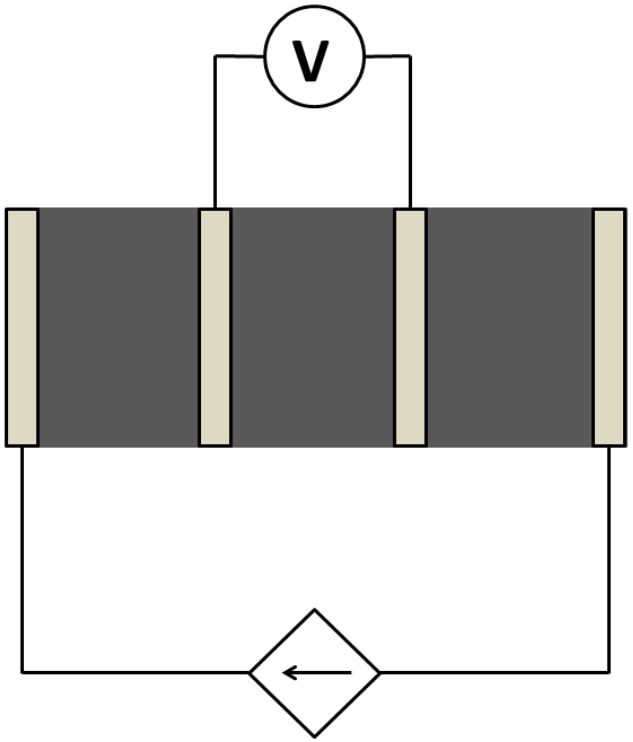
- uređenje naboja
- antiferomagnetizam



uređenje naboja ⟹ feroelektricitet?

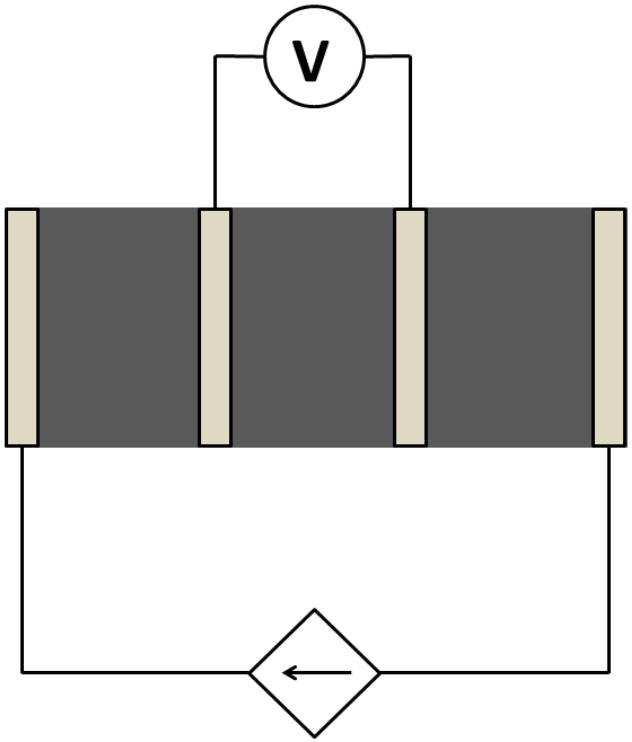
feroelektricitet
+
antiferomagnetizam
⟹ multiferoik?

Mjerenje otpora

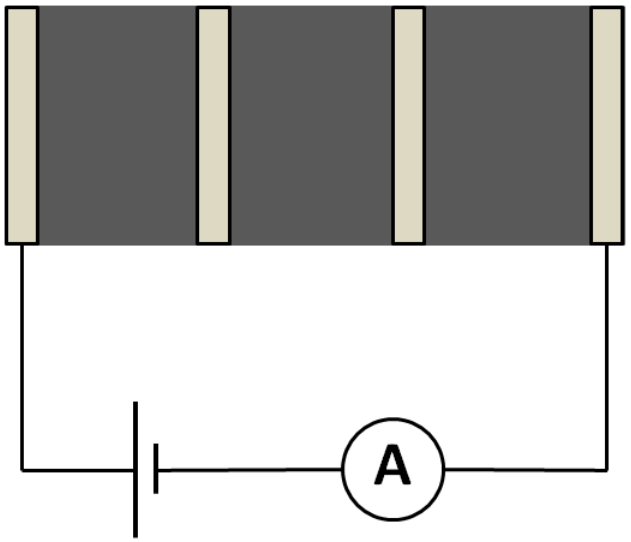


metoda četiri kontakta

Mjerenje otpora



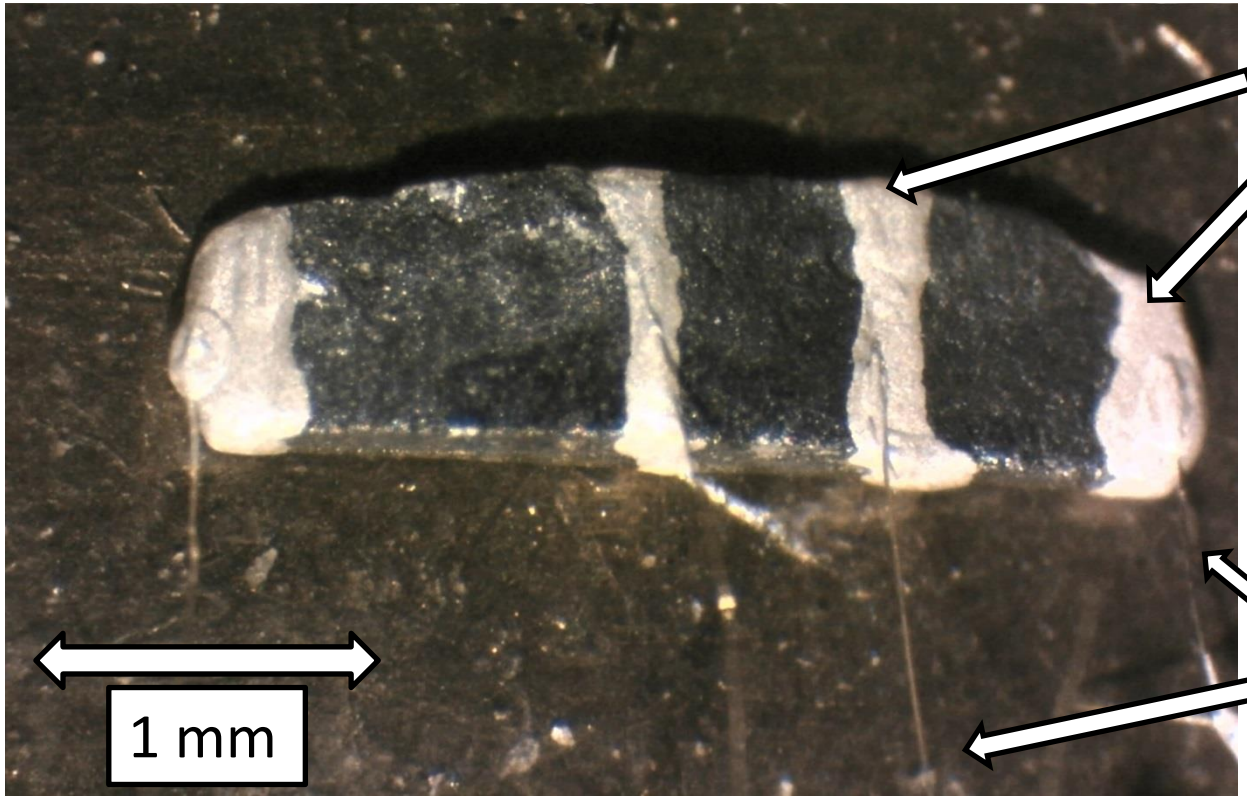
metoda četiri kontakta



metoda dva kontakta

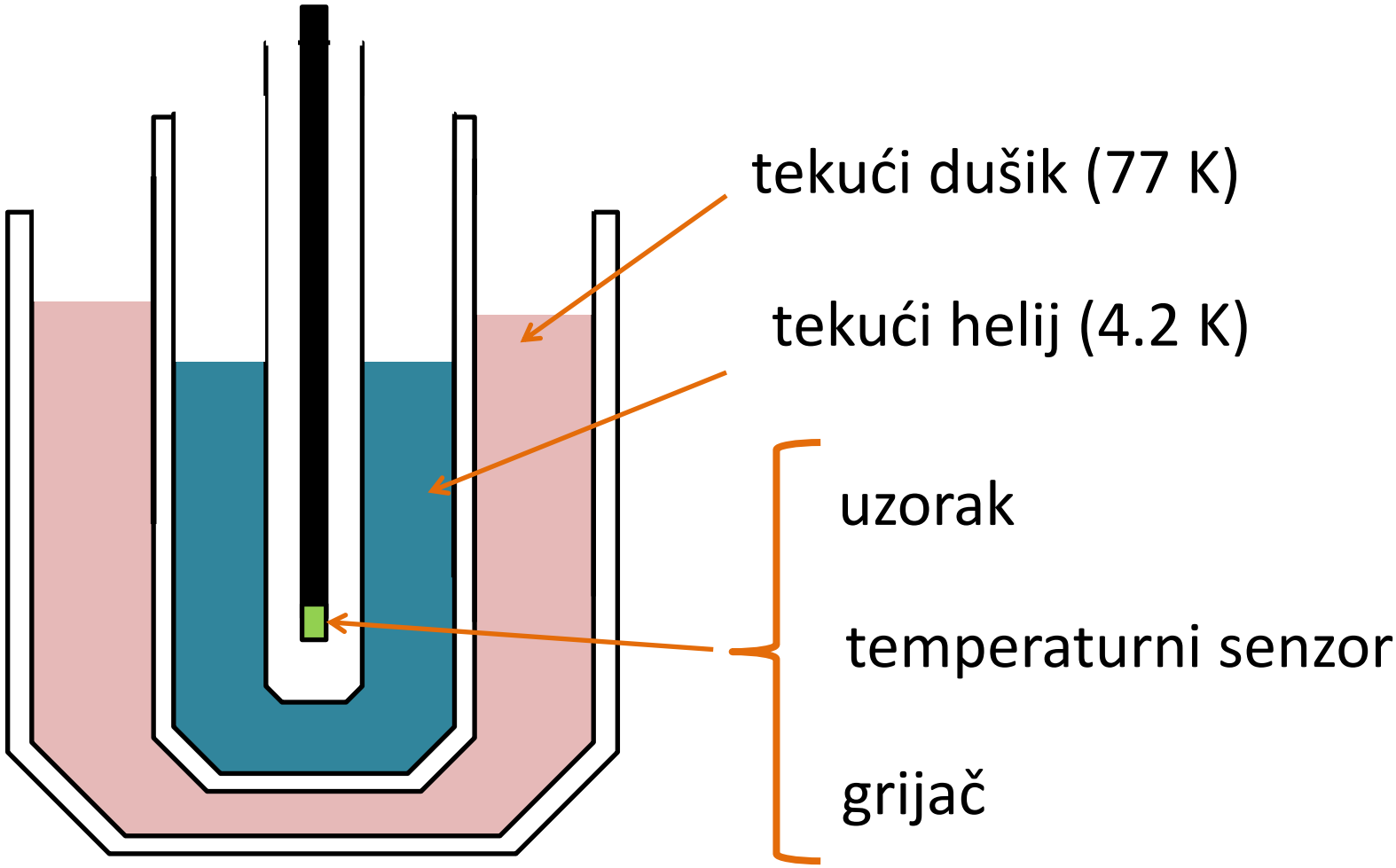
Uzorak

- polikristalna keramika $\mathrm{La}_{1-x}\mathrm{Ca}_x\mathrm{MnO}_3,\ x = 0.7$
- anularni kontakti od vodljive srebrne paste

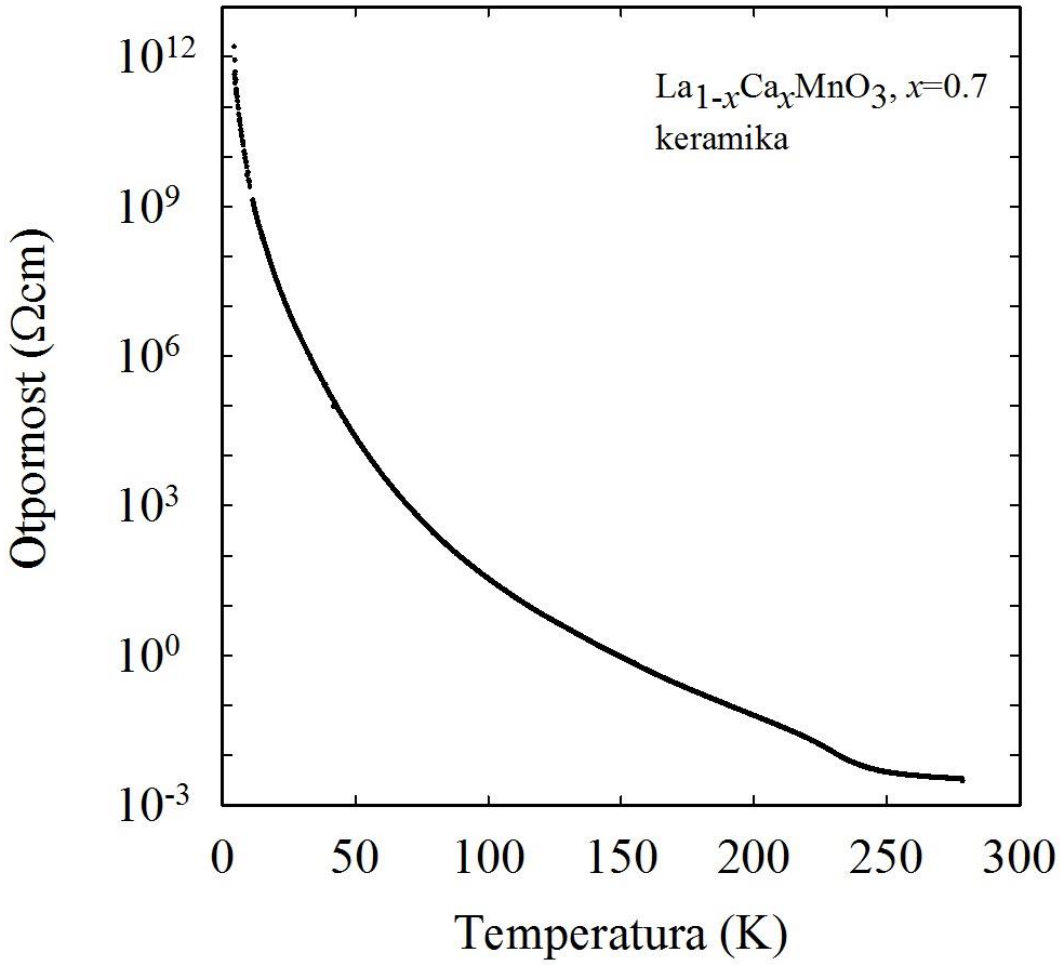


Kriostat

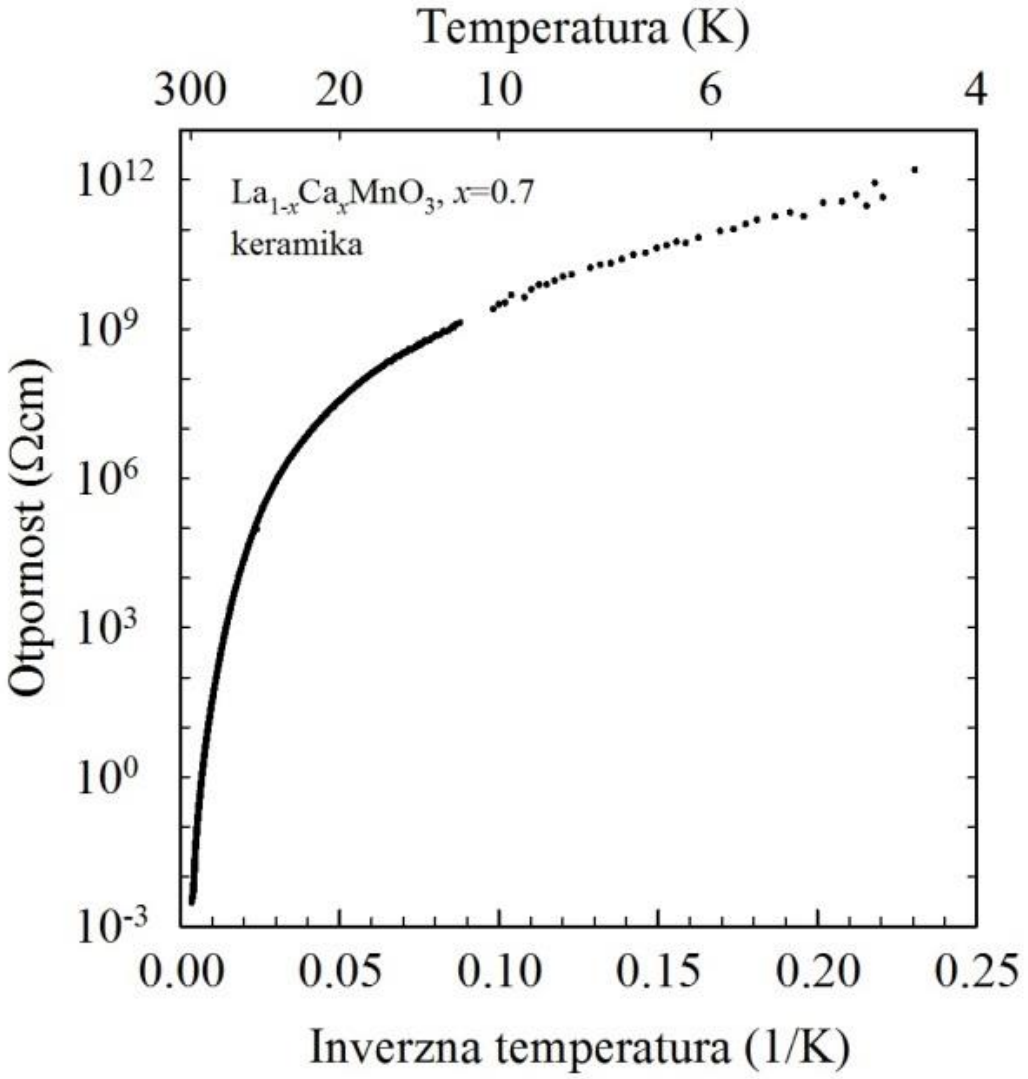
- hlađenje uzorka do 4.2 K



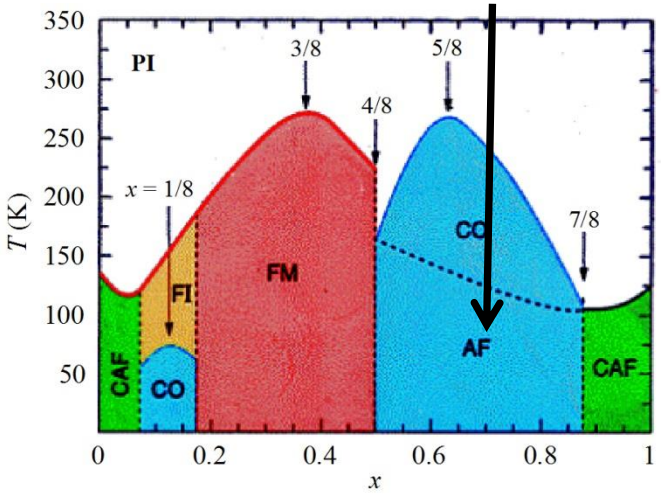
Otpornost


$La_{1-x}Ca_xMnO_3$, x=0.7
keramika
Otpornost (Ωcm)
10^{12}
10^{9}
10^{6}
10^{3}
10^{0}
10^{-3}
0
50
100
150
200
250
300
Temperatura (K)

Otpornost

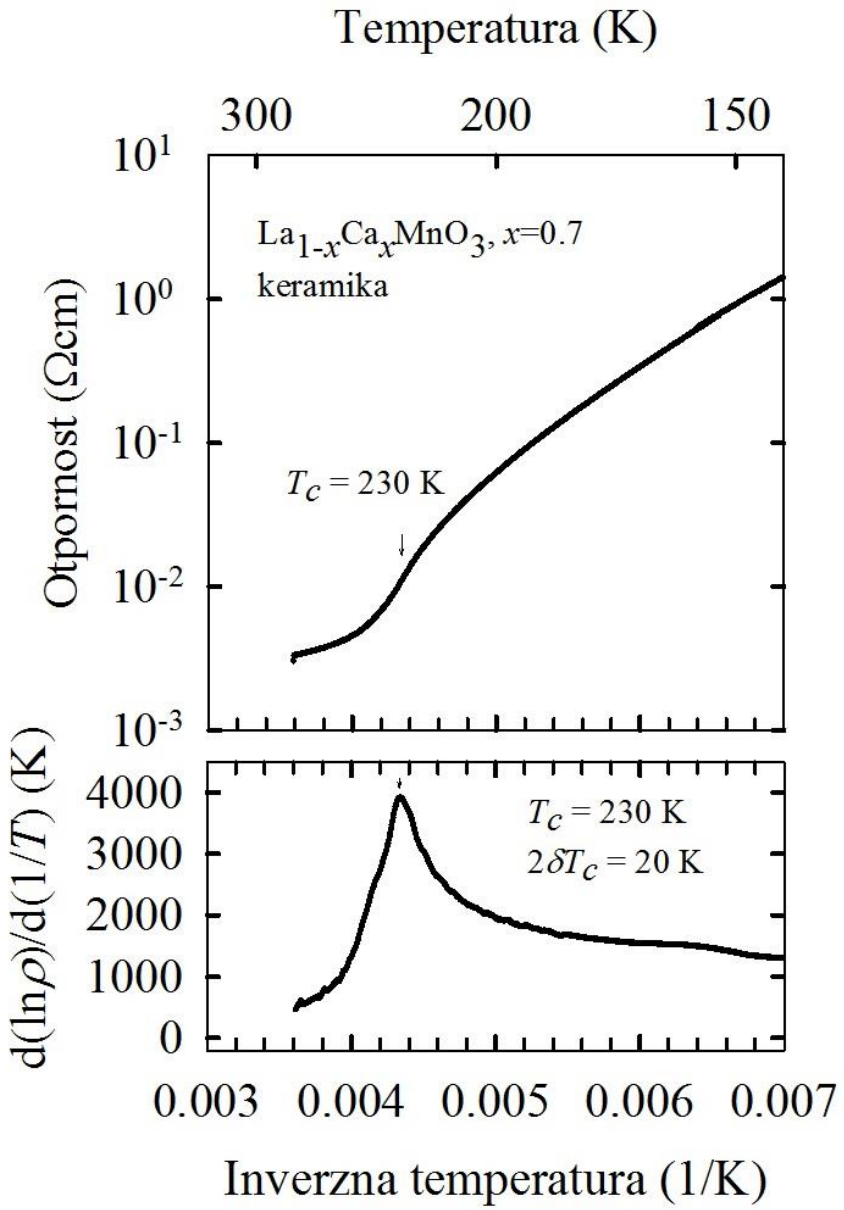

Temperatura (K)
300
20
10
6
4
10^{12}
10^{9}
10^{6}
10^{3}
10^{0}
10^{-3}
$La_{1-x}Ca_xMnO_3$, x=0.7
keramika
Otpornost (Ωcm)
0.00
0.05
0.10
0.15
0.20
0.25
Inverzna temperatura (1/K)

Otpornost

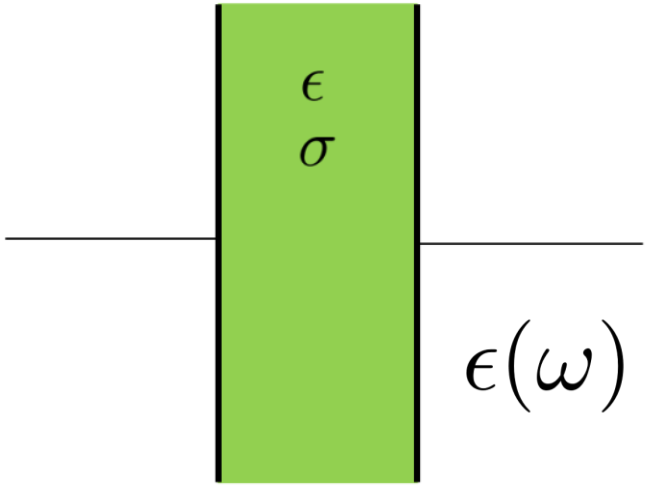


Mogući uzroci širine vrha:

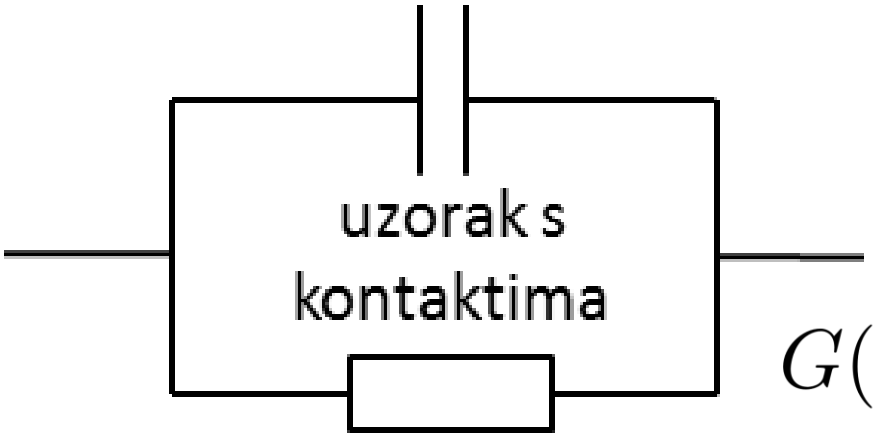
- polikristal
- nehomogeno supstituiranje



Mjerenje kapaciteta



$$\epsilon(\omega) = \epsilon'(\omega) - i\epsilon''(\omega) = \frac{\sigma(\omega) - \sigma_0}{i\omega\epsilon_0}$$

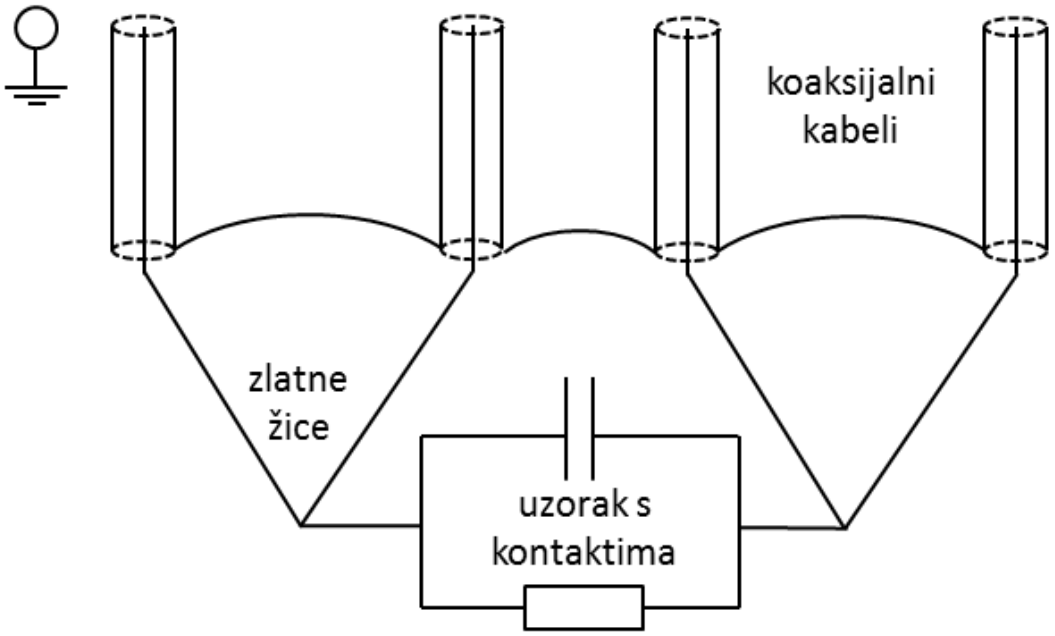


admitancija $Y = \frac{1}{Z}$

$$Y = G + iB$$

$$G(\omega) = \frac{1}{R(\omega)}, \; B(\omega) = \omega C(\omega)$$

LCR metar

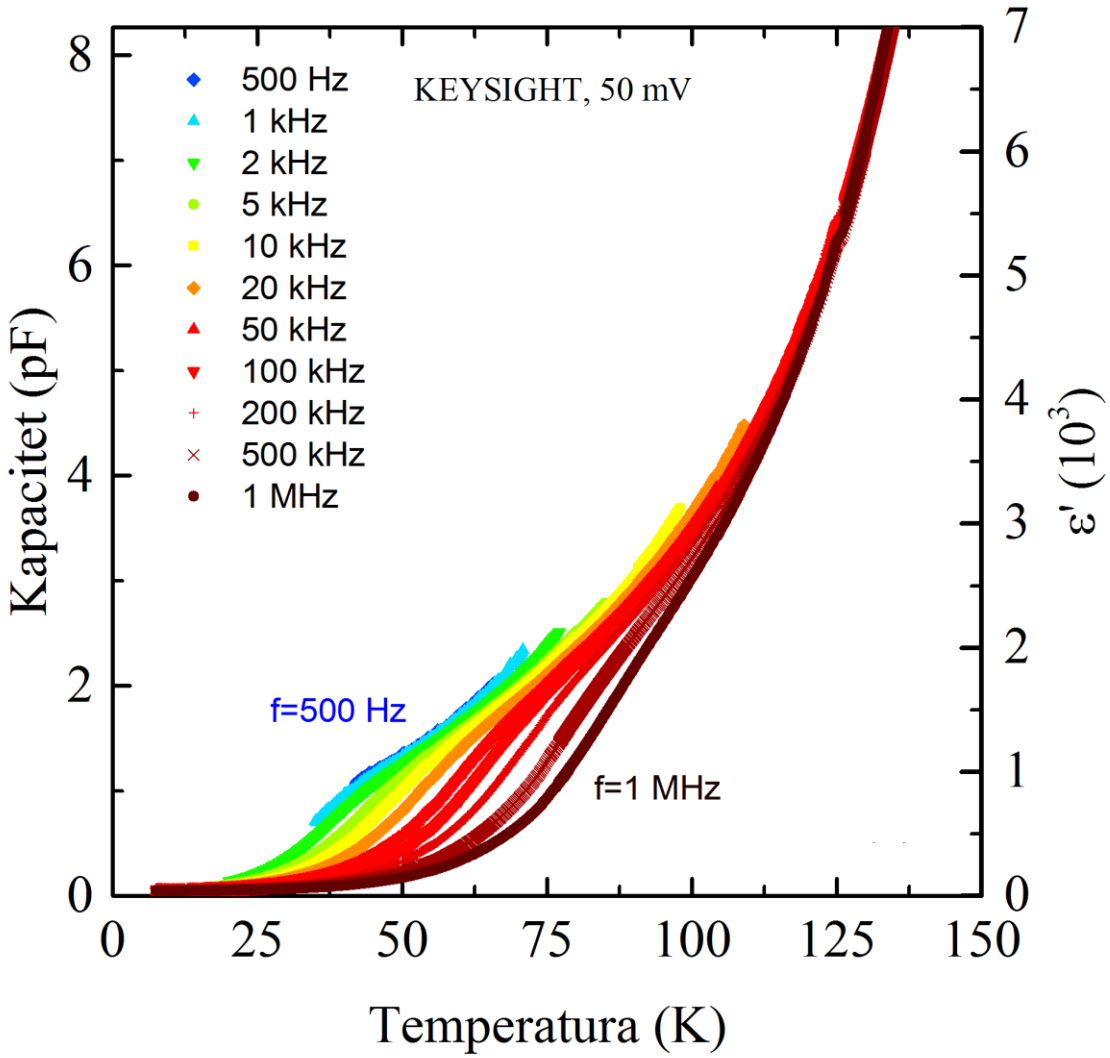


LCR metar ⟶ admitancija $Y = \frac{1}{Z}$

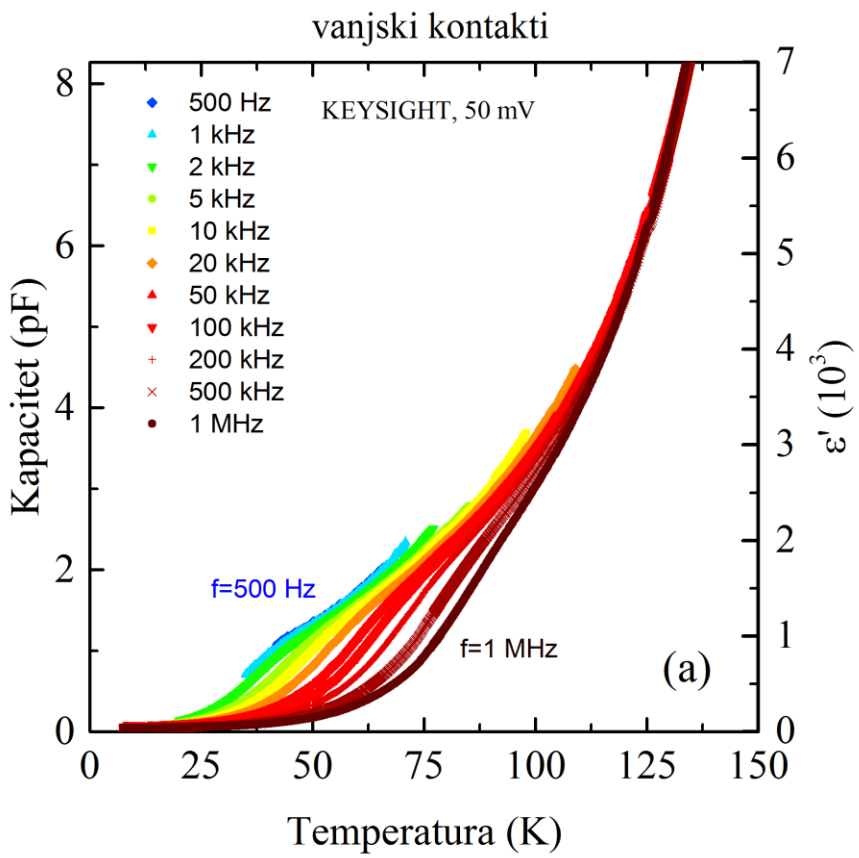
20 Hz – 1 MHz

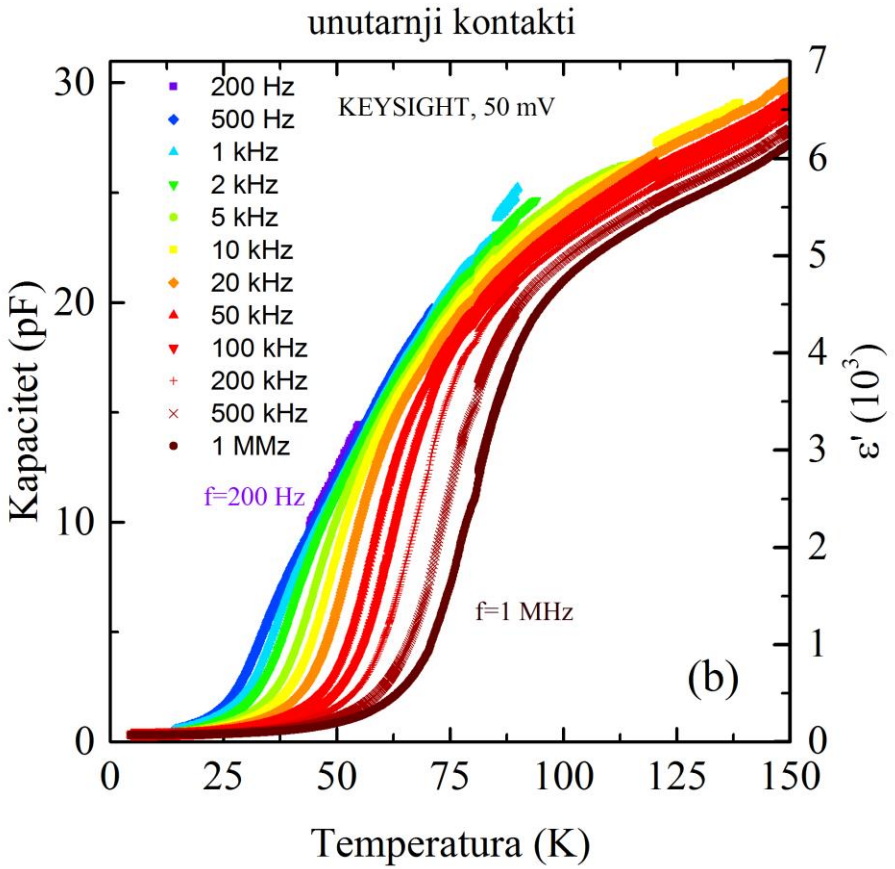
Mjerenje kapaciteta

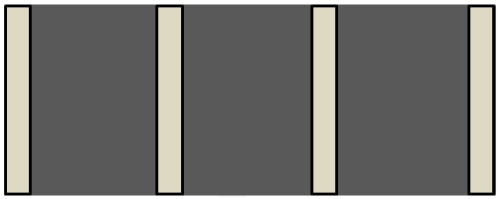
$$\epsilon' = \frac{l}{S}\frac{C}{\epsilon_0}$$



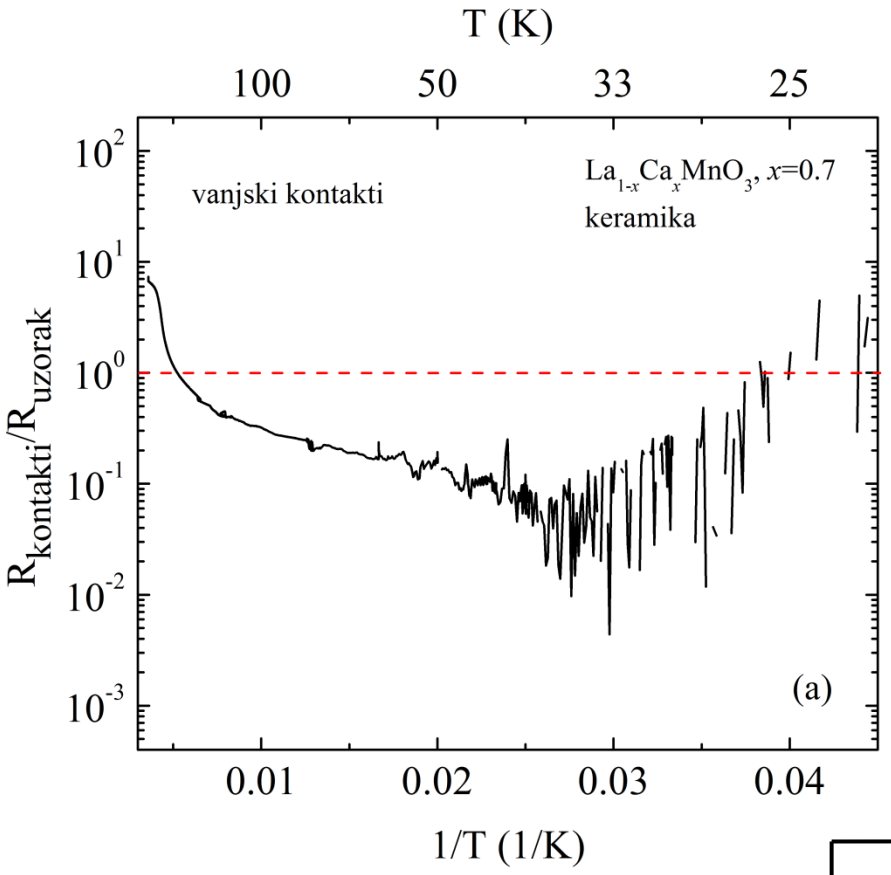
Utjecaj kontakata?

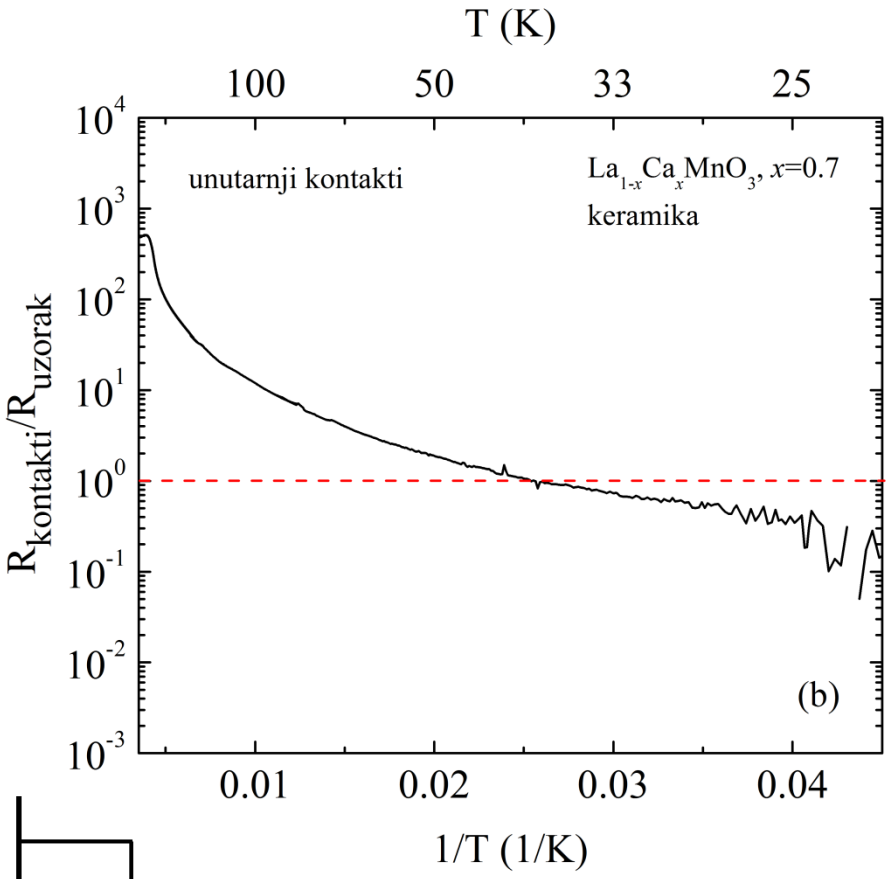


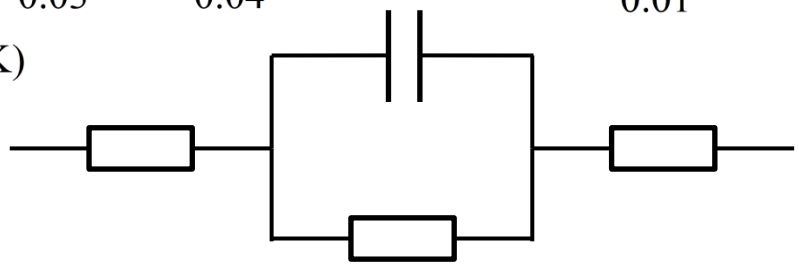




Otpor kontakata







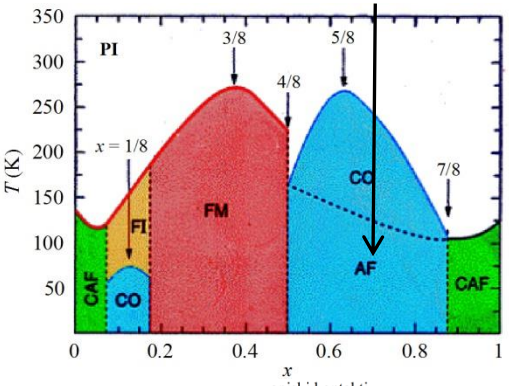
Zaključak

$$La_{1-x}Ca_xMnO_3,\ x = 0.7$$

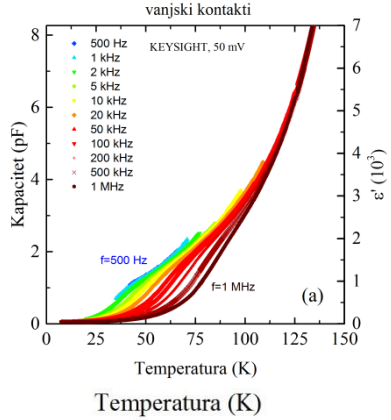
- fazni prijelaz na 230 K – uređenje naboja
- frekventna disperzija dielektrične funkcije ϵ'
  - karakteristično za relaksorske feroelektrike

- dodatna provjera:
  - s kontaktima od drugog materijala
  - s uzorkom koji ima zrna keramike

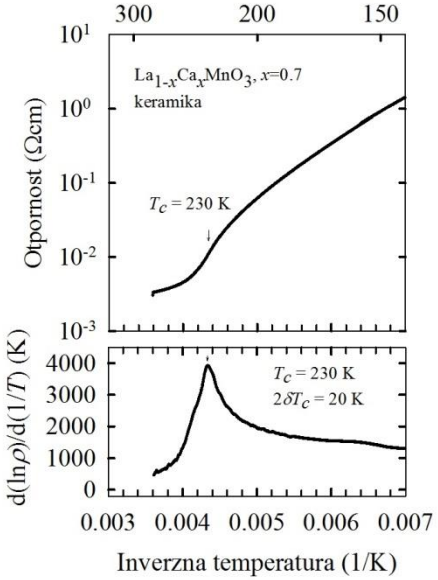
  drukčije veličine



vanjski kontakti



Temperatura (K)



Zahvale

Zahvaljujem se svom mentoru dr. sc. Tomislavu Iveku na uloženom trudu i prenesenom znanju pri izradi ovog seminara.

Literatura

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M. Pinterić et al. *Phys. Rev. B* **90**, 195139 (2014)

Hvala na pažnji!

Dodatak - dielektrična funkcija

$$\nabla \times \mathbf{H}(t) = \mathbf{j}_f(t) + \frac{\partial \mathbf{D}(t)}{\partial t} \qquad \mathbf{j}_f(t) = \sigma_0 \mathbf{E}(t)$$

$$\mathbf{H}(t) = \mathbf{H}e^{i\omega t},\ \mathbf{E}(t) = \mathbf{E}e^{i\omega t},\ \mathbf{D}(t) = \epsilon_0 \epsilon(\omega)\mathbf{E}e^{i\omega t}$$

$$\nabla \times \mathbf{H}(t) = (\sigma_0 + i\omega\epsilon_0\epsilon(\omega))\mathbf{E}(t)$$

$$\Rightarrow \quad \sigma(\omega) = \sigma_0 + i\omega\epsilon_0\epsilon(\omega)$$

$$\epsilon(\omega) = \epsilon'(\omega) - i\epsilon''(\omega) = \frac{\sigma(\omega) - \sigma_0}{i\omega\epsilon_0}$$

T. Ivek (2004). *Val gustoće naboja u kvazi-jednodimenzionalnim kupratima* (Diplomski rad).

Dodatak - dielektrična funkcija

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$$Y = G + iB$$

$$G(\omega) = \frac{1}{R(\omega)}, \; B(\omega) = \omega C(\omega)$$

$$\epsilon' = \frac{l}{S} \frac{C}{\epsilon_0}$$

T. Ivek (2004). *Val gustoće naboja u kvazi-jednodimenzionalnim kupratima* (Diplomski rad).