Visualizing out-of-equilibrium superconductivity

Claude Chapelier, *INAC, CEA - UGA*
Eduard Driessen, *IRAM*

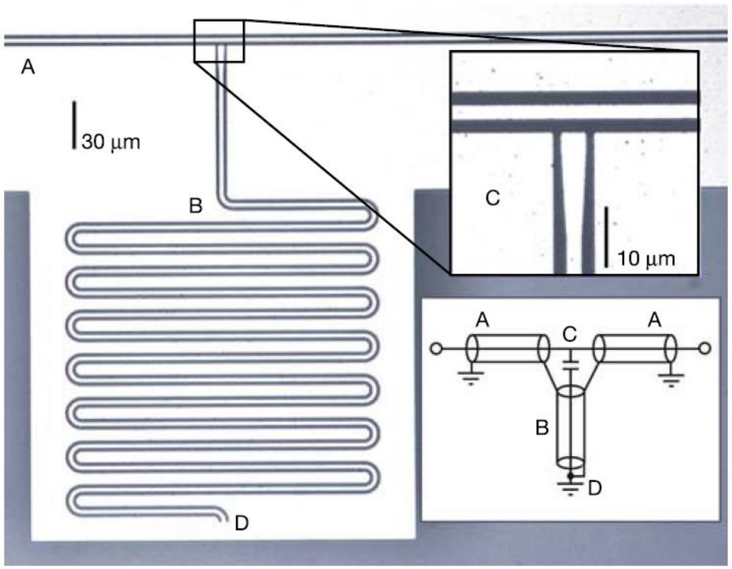
TiN

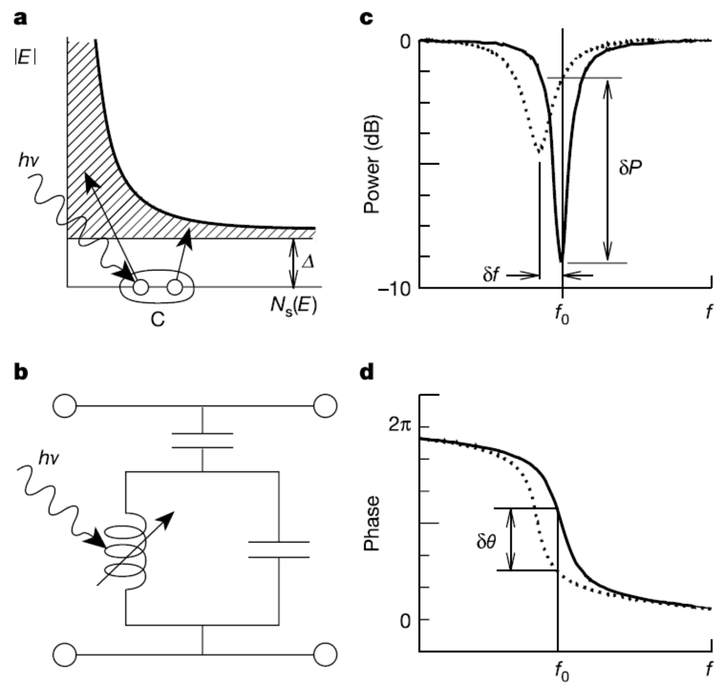
1- Superconducting Photon detector
2- Critical current microscopy

INSTITUT NANOSCIENCES ET CRYOGÉNIE

UNIVERSITÉ Grenoble Alpes

Superconducting photon detector





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P.K. Day et *al.*, *Nature* ***425*** , 817 (2003)

Superconducting photon detector

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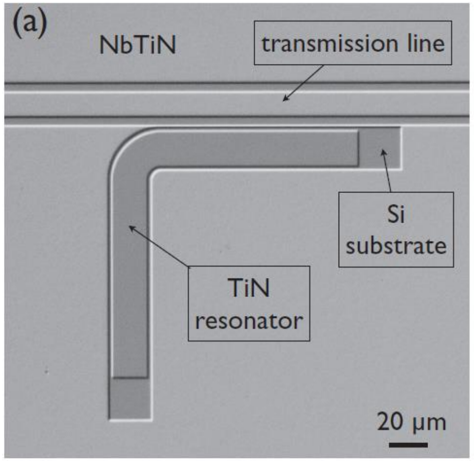

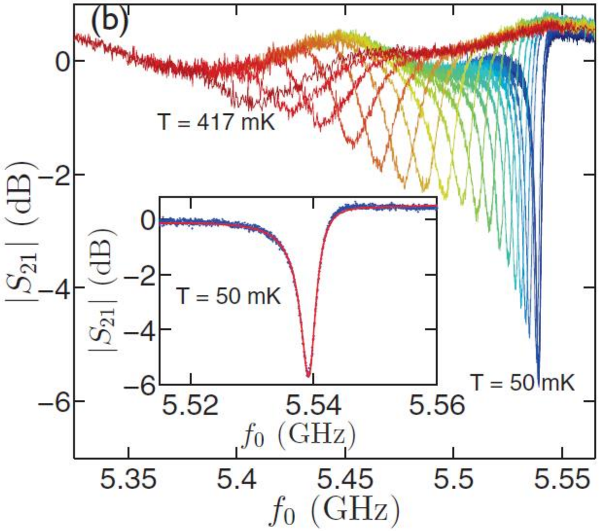

P.C.J.J. Coummou et *al.*, *Phys. Rev.B* ***88***, 180505(R), (2013)

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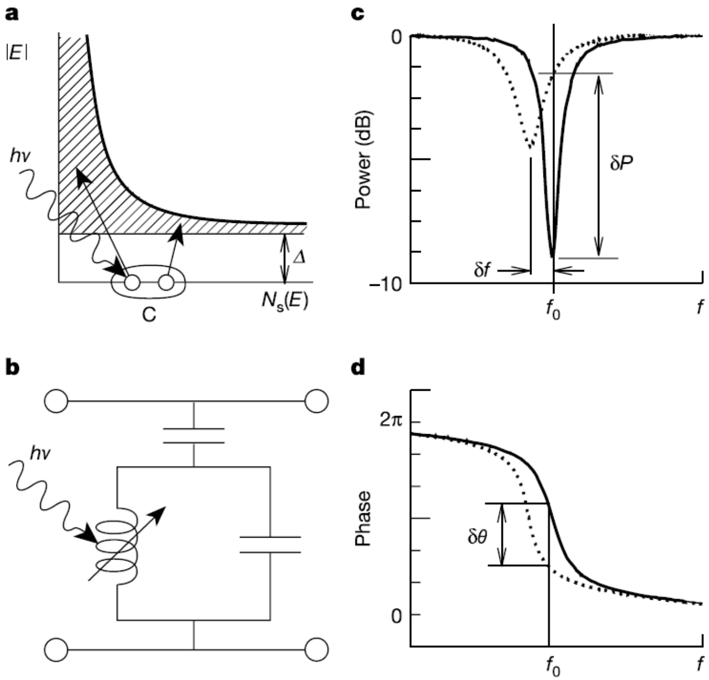

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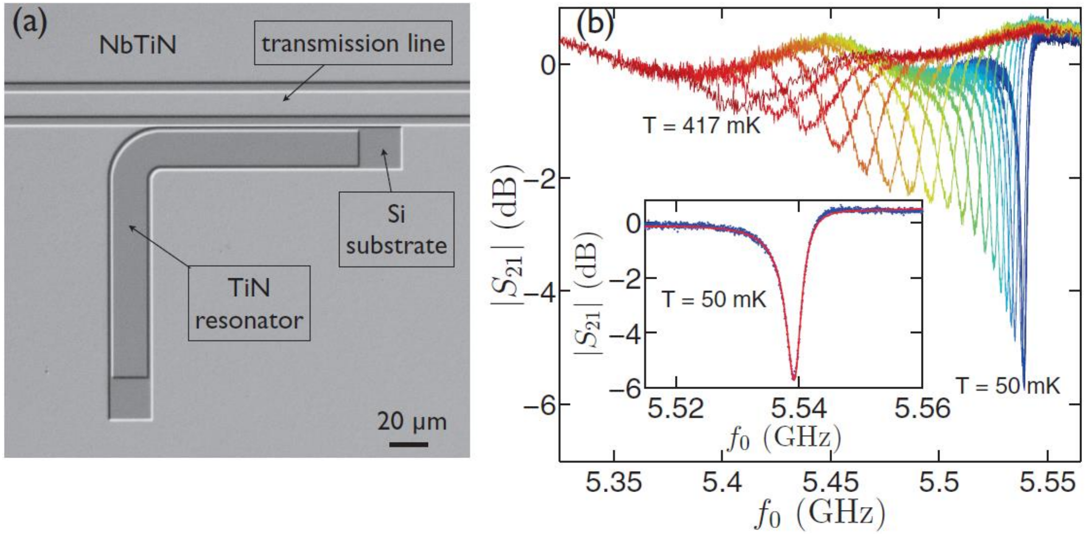

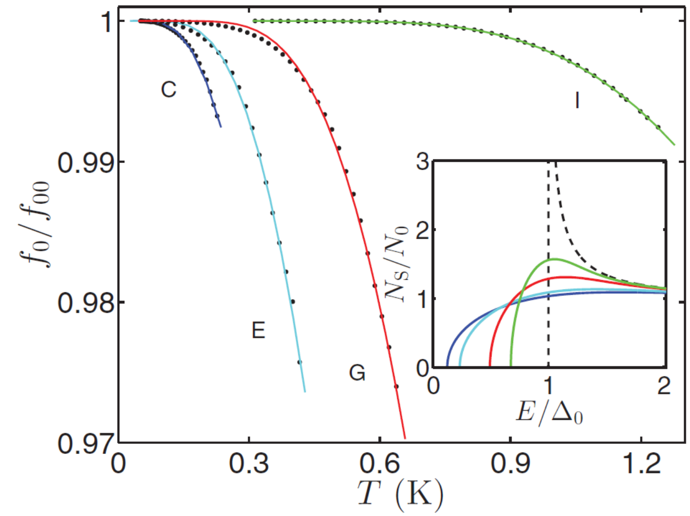

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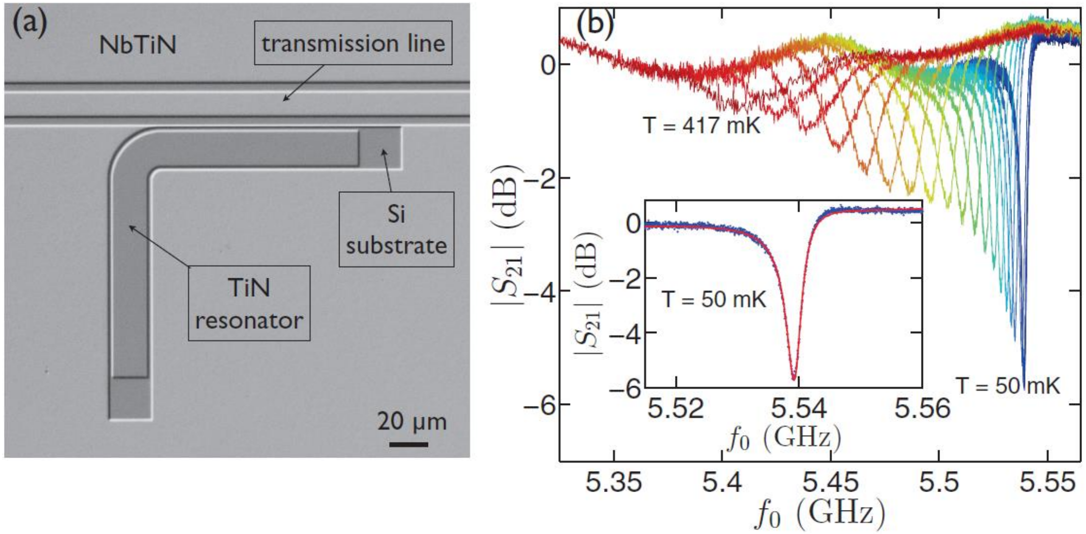

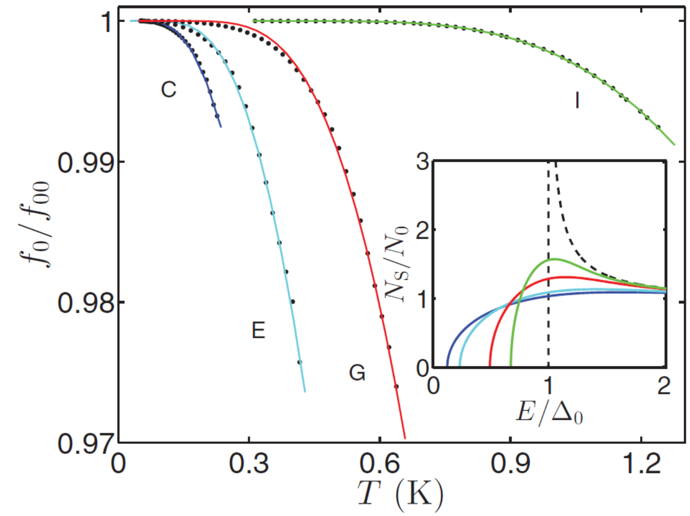

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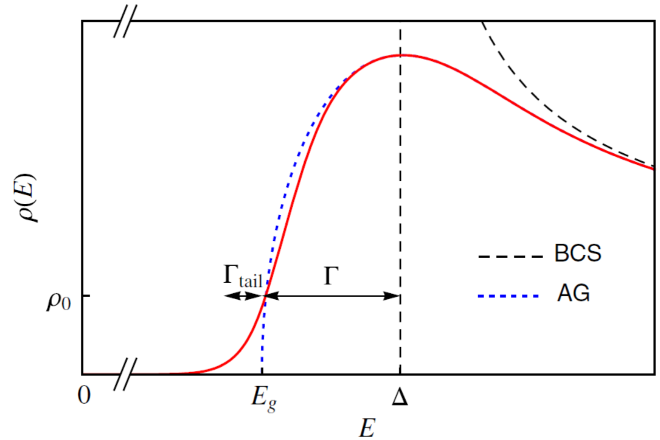

M.V. Feigelman and M.A. Skvortsov, *Phys. Rev. Lett.* ***109***, 147002 (2012)
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A. Bespalov et al, *Phys. Rev. B* ***93*,** 104521 (2016)
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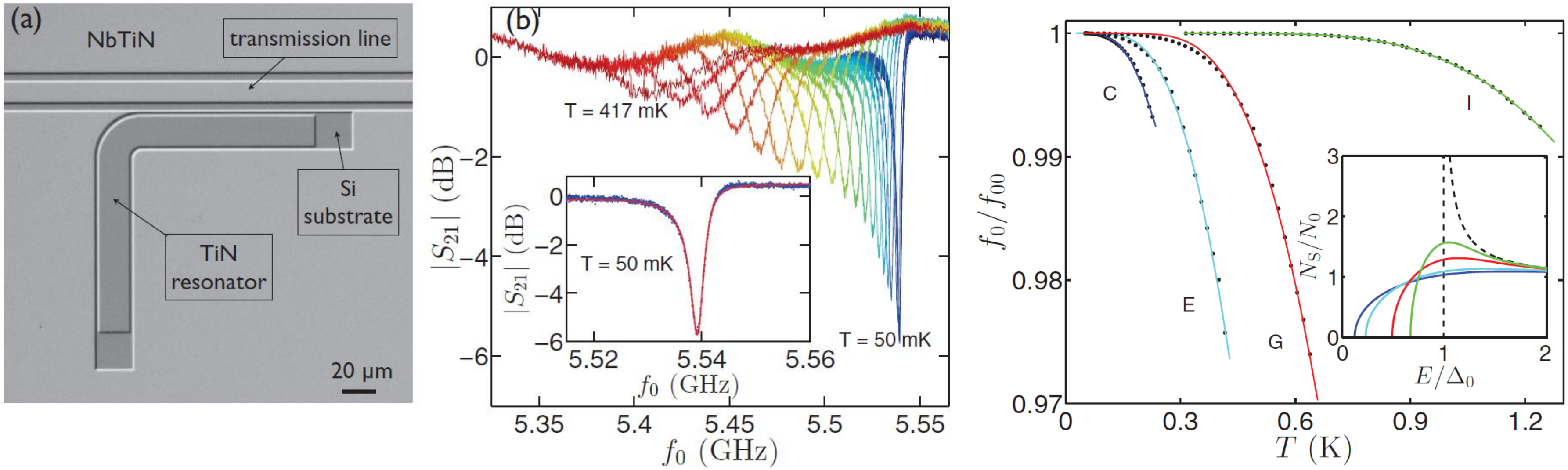

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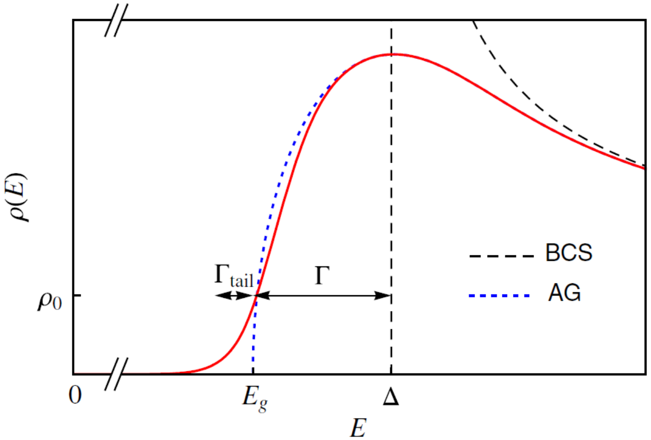

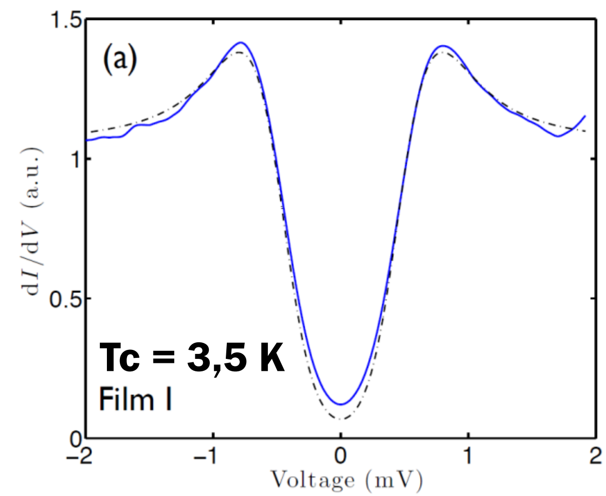

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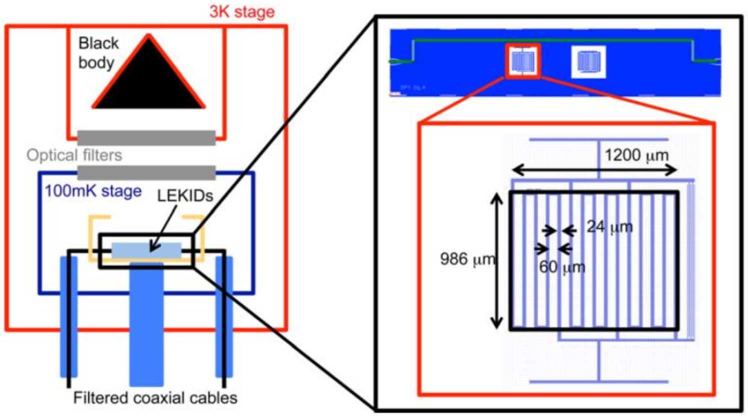

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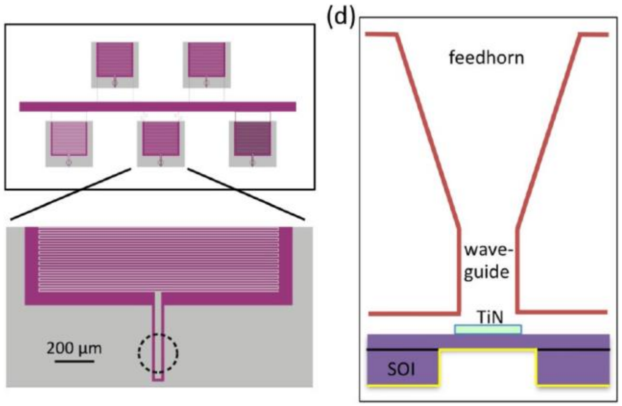

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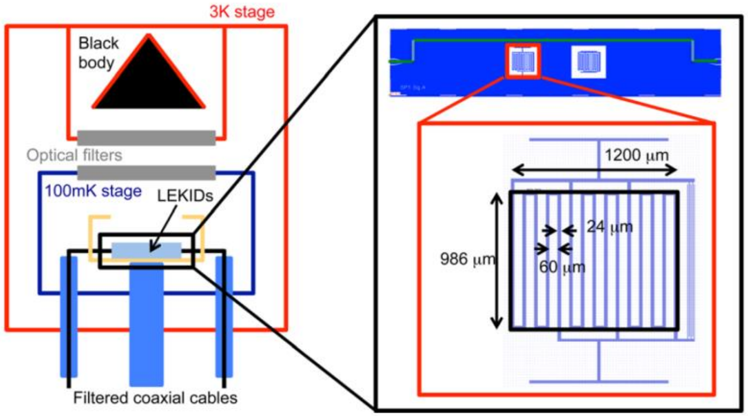

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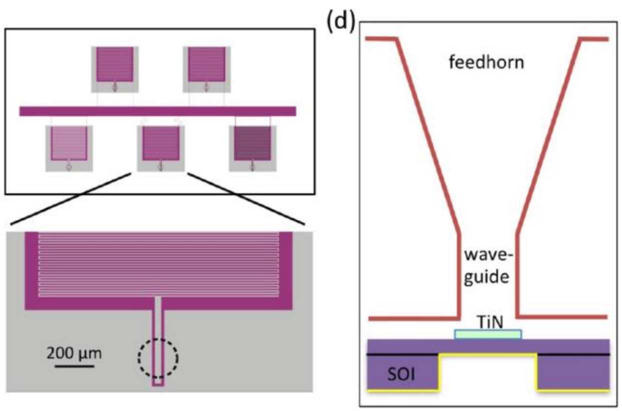

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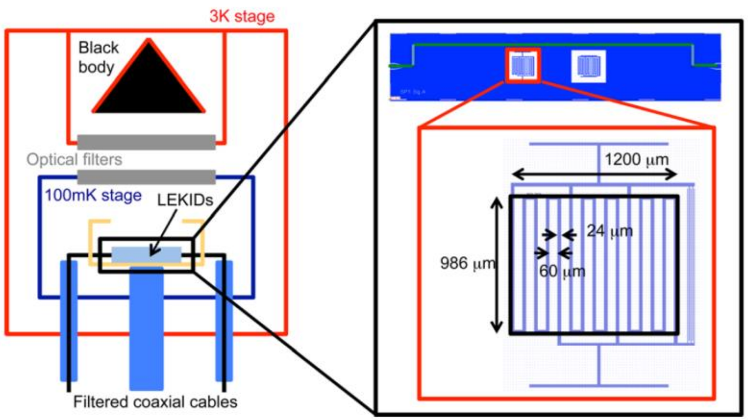

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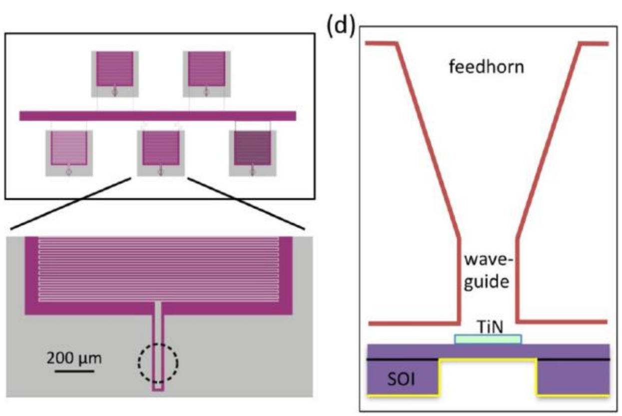

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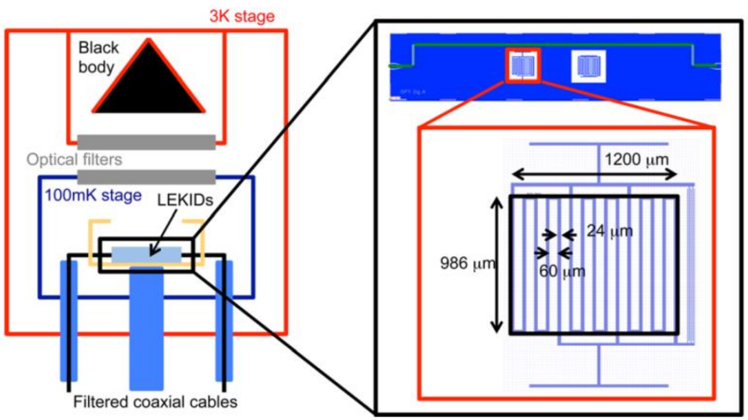

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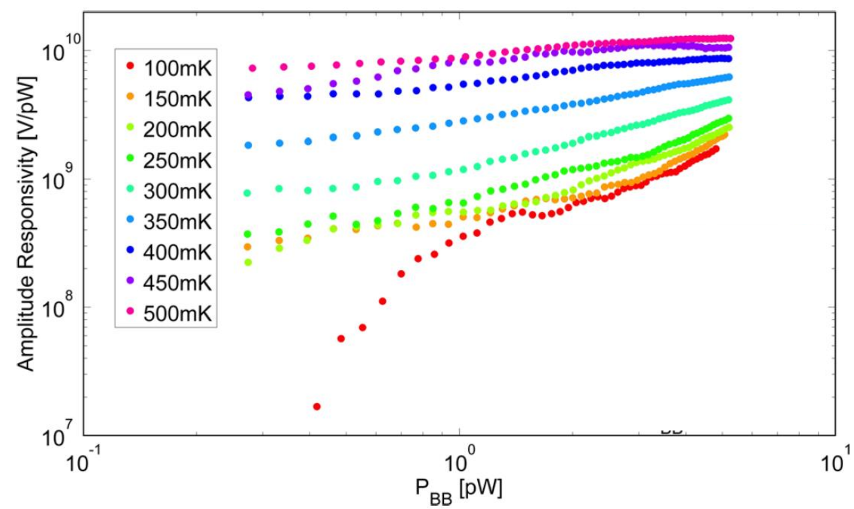

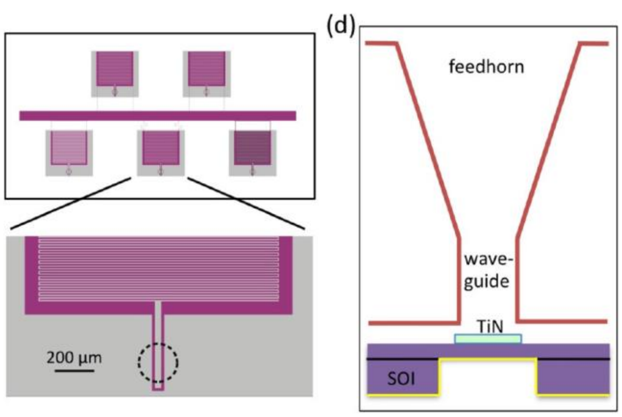

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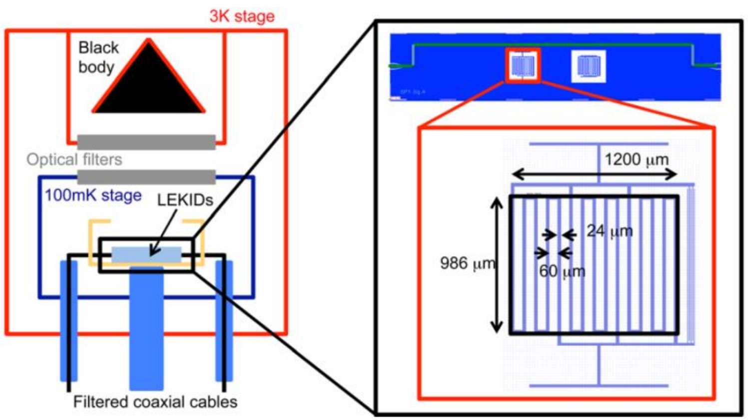

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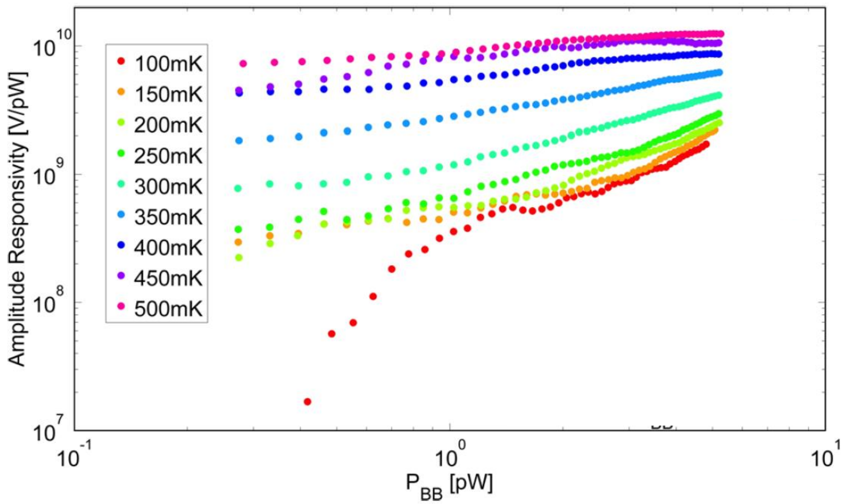

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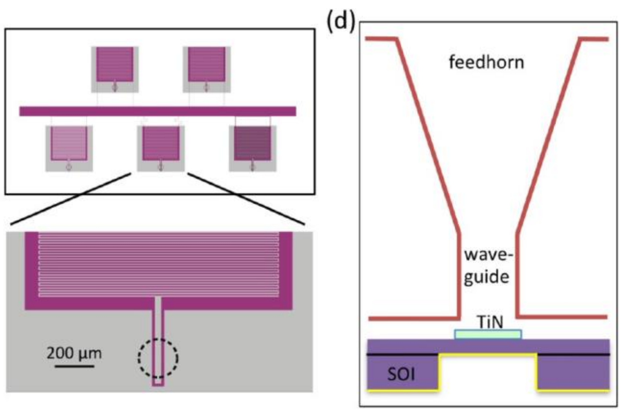

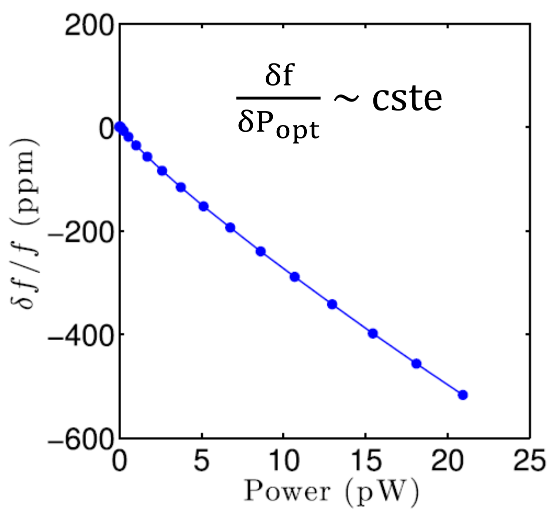

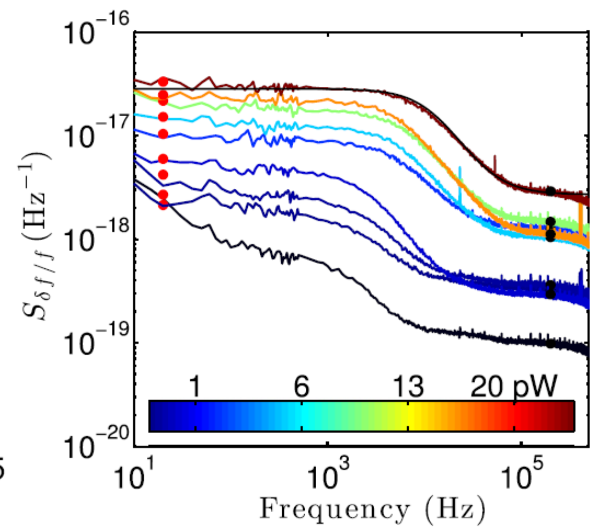

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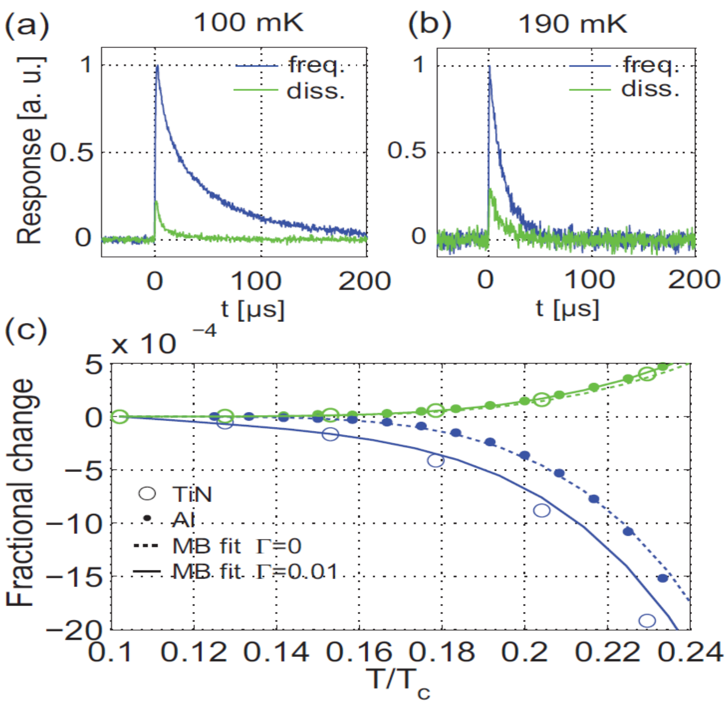

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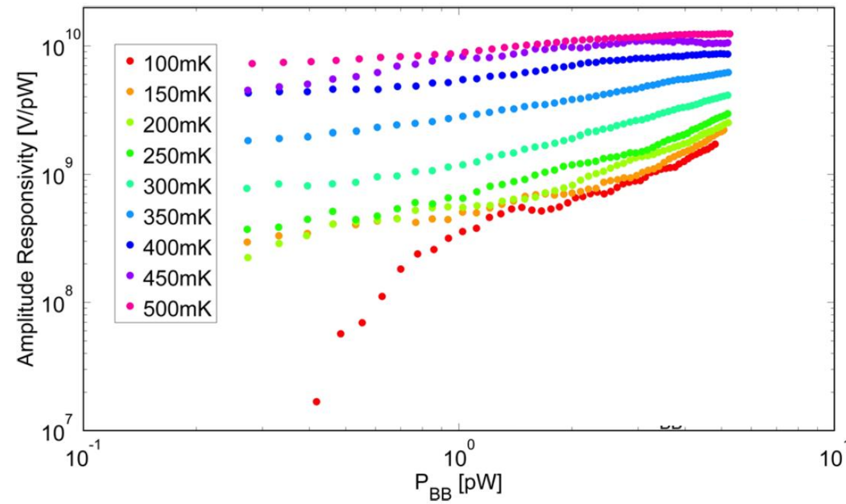
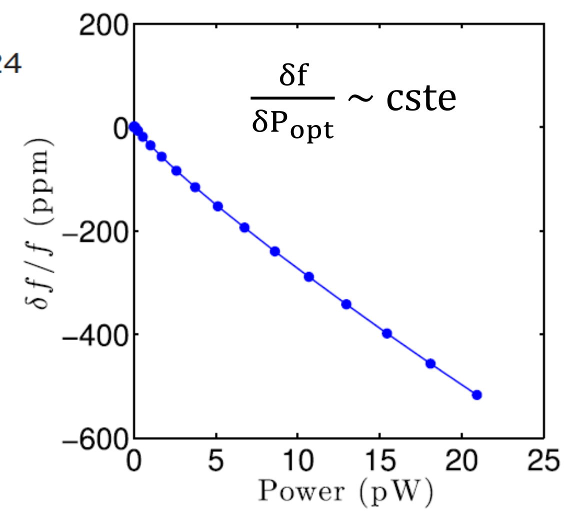
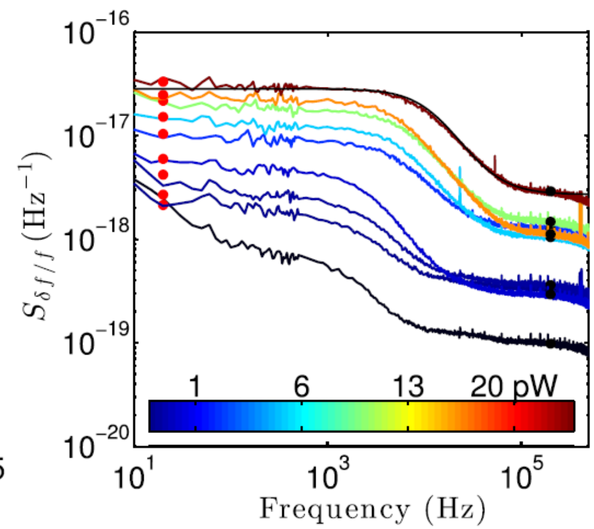




$$\frac{\delta f}{\delta P_{opt}} \sim \text{cste}$$



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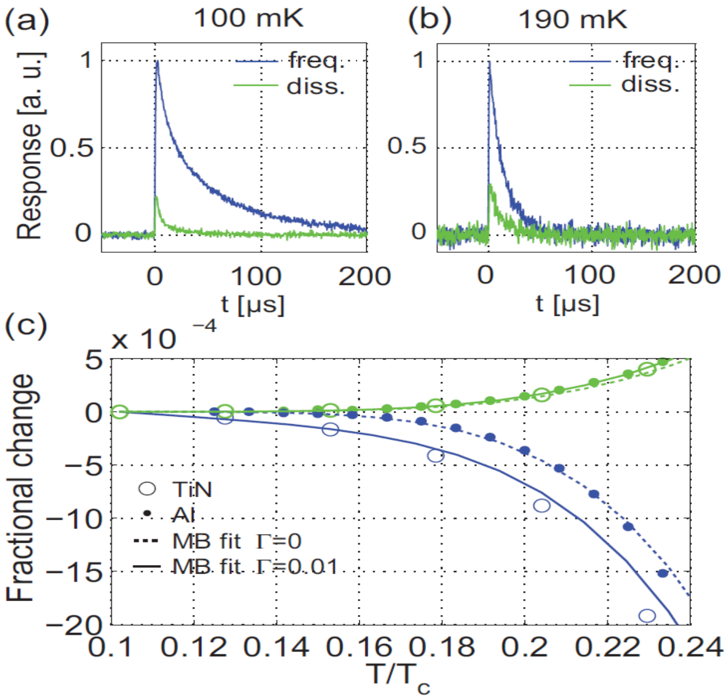

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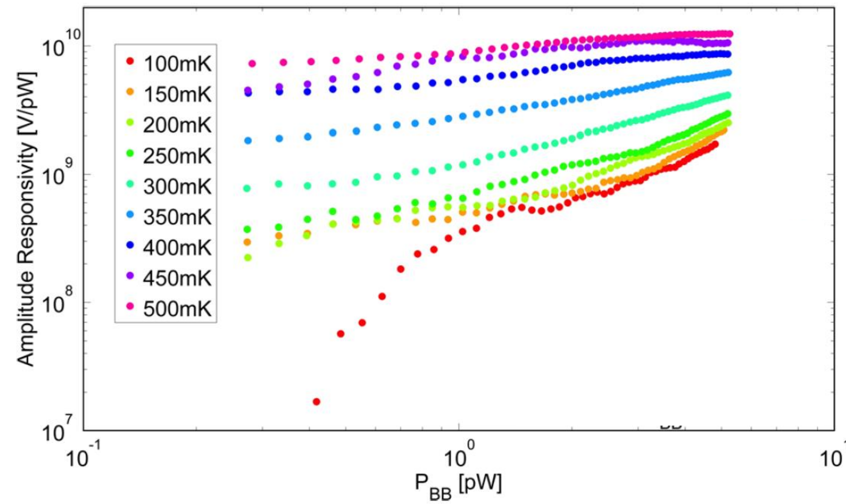

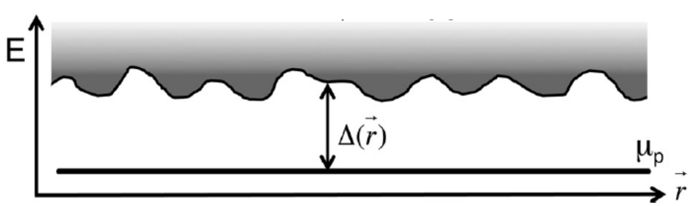

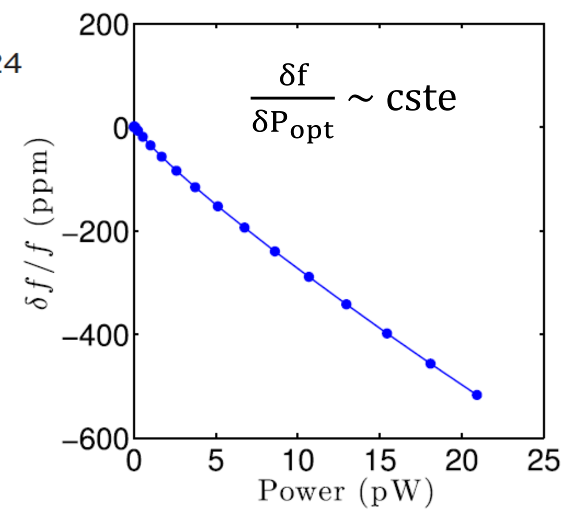

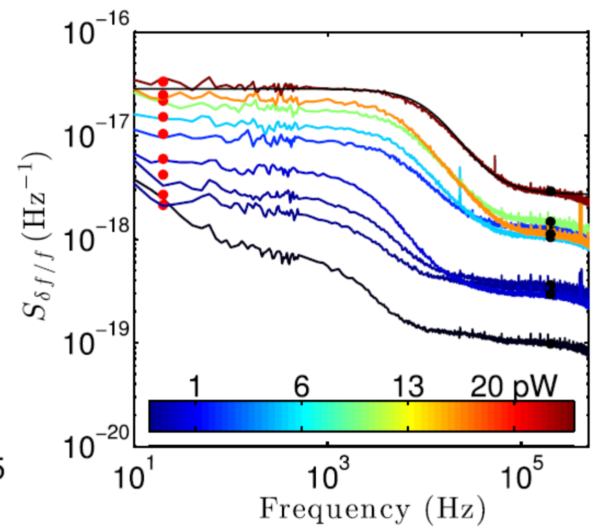

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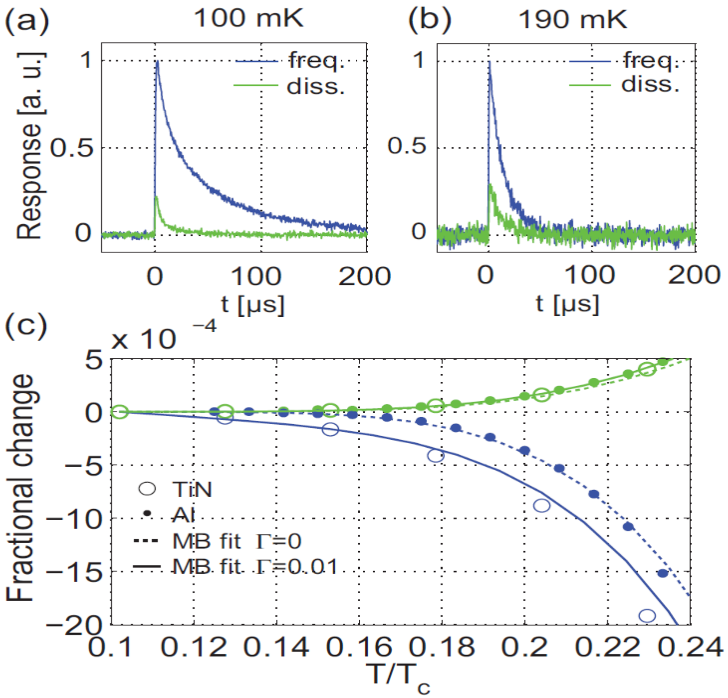

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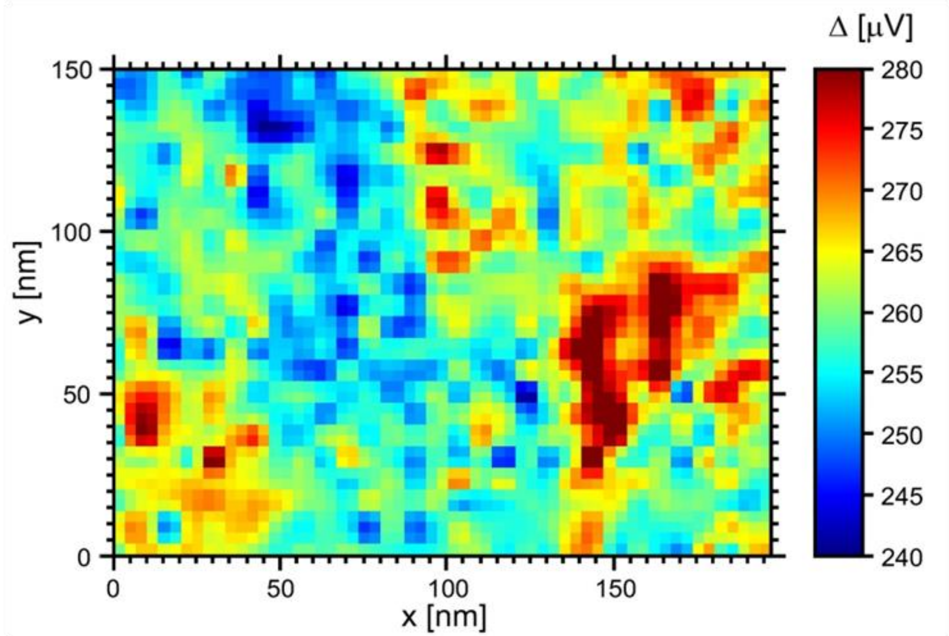

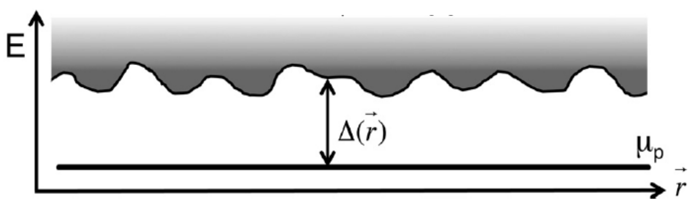

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Sacépé et al., *Phys. Rev. Lett.* ***101***, *157006 (2008)*

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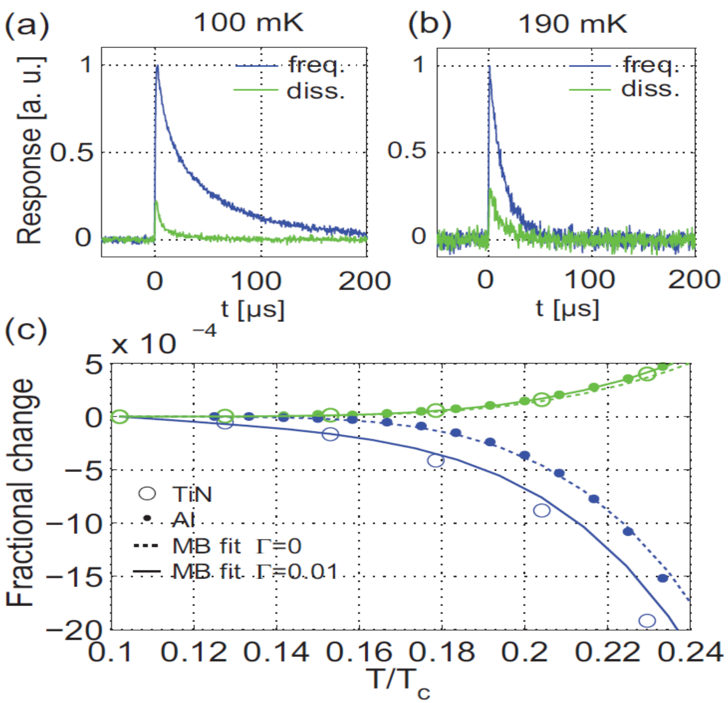

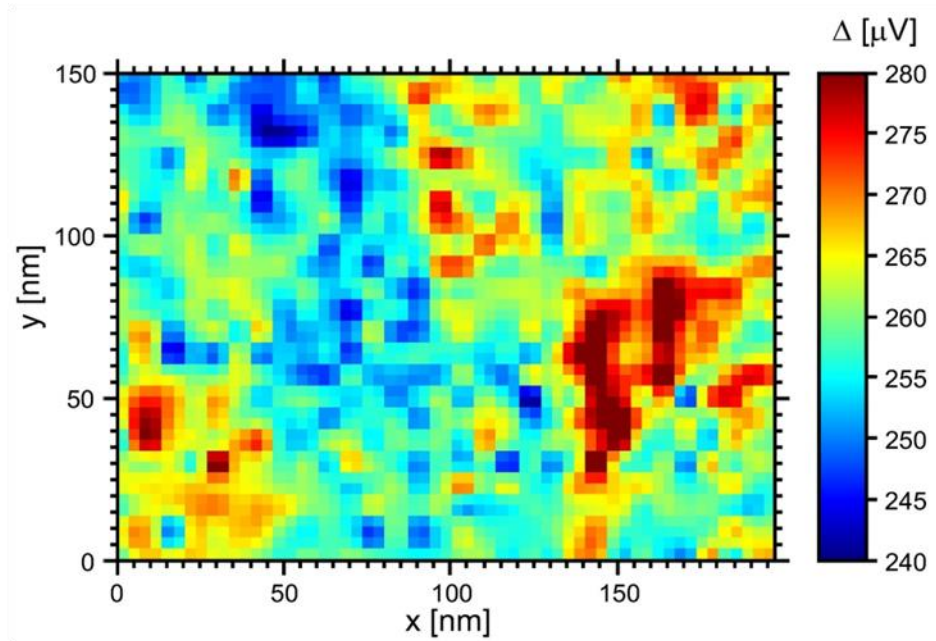

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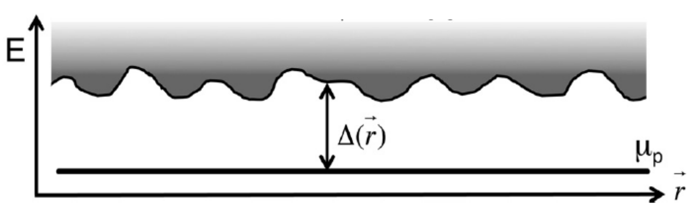

Understanding the recombination physics in TiN is required

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TiN

1- Superconducting Photon detector

2- Critical current microscopy

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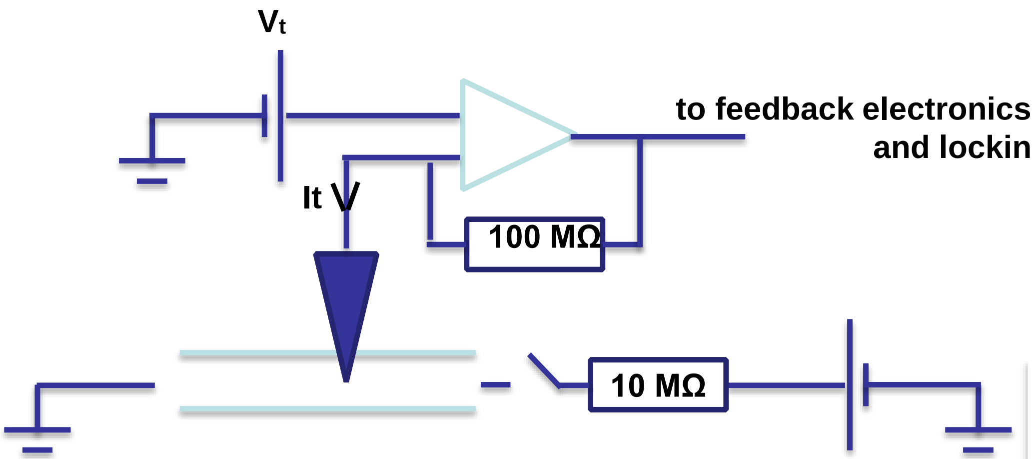
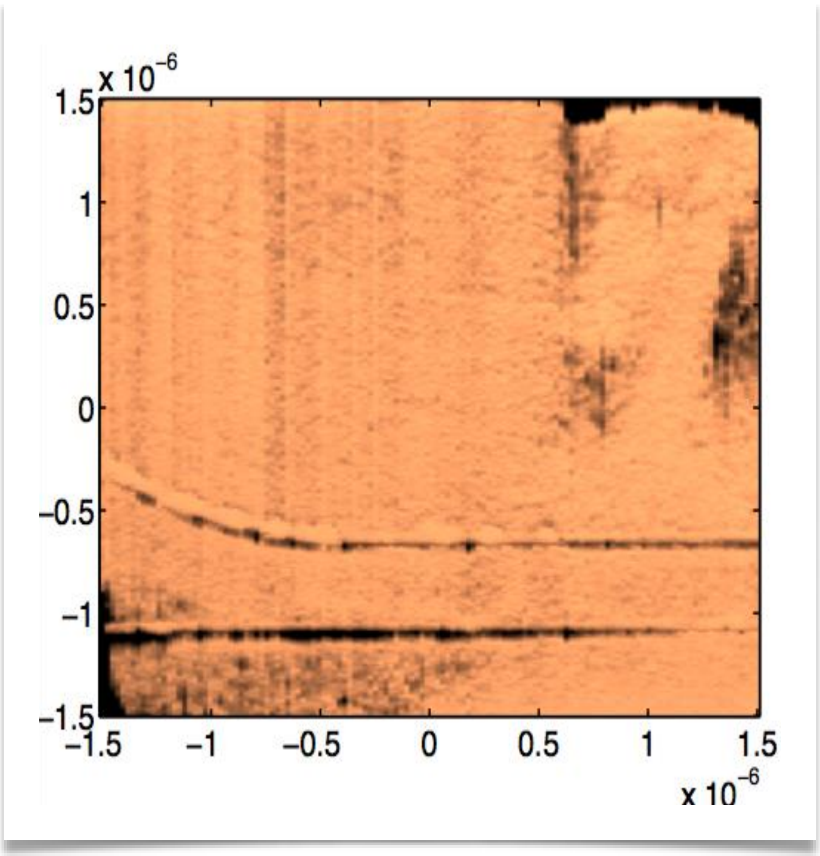


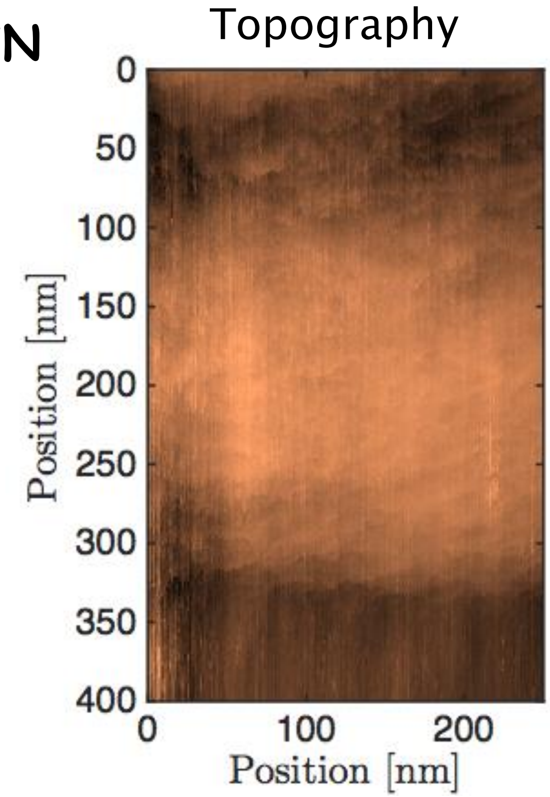


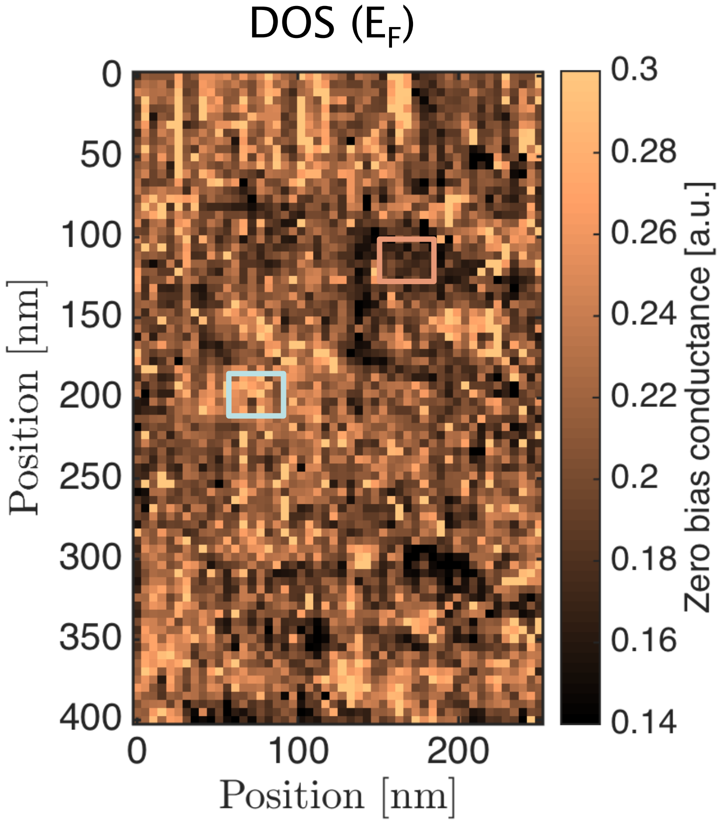
- Device fabrication in Kavli Nanolab
- Nanowire: 5nm x 200 nm x 4 μm
- T_c = 1.5 K, R_s = 1.5 kΩ
- Δ = 250 μV, Δ/T_c = 1.9

E. Driessen et al., *unpublished*

STM/STS on a nanowire

TiN





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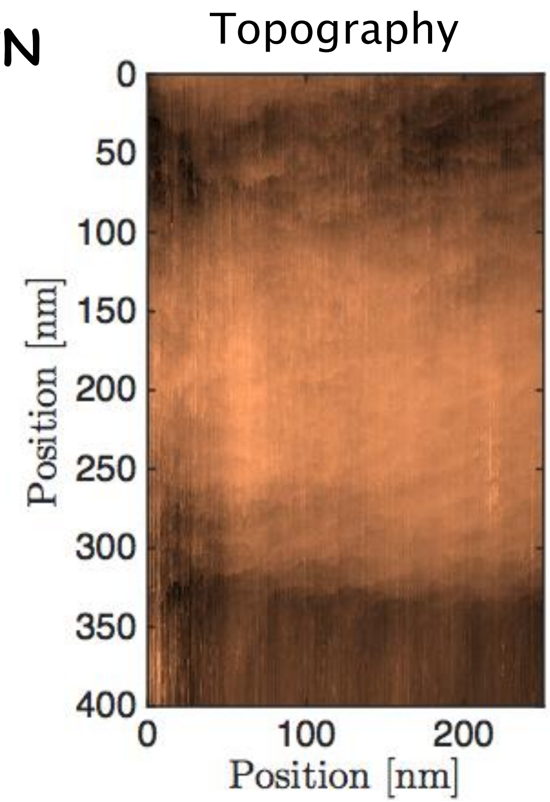

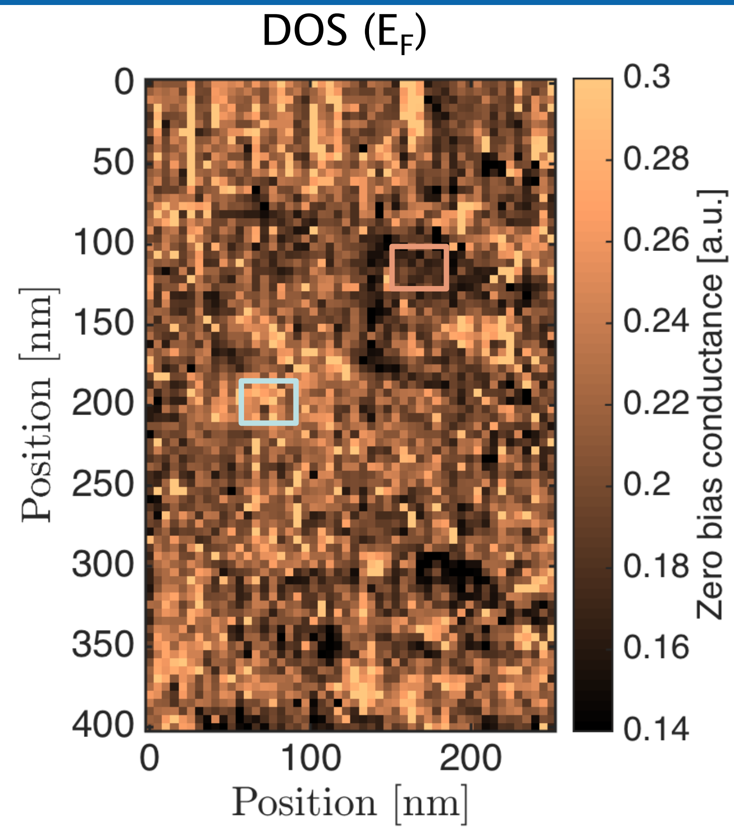

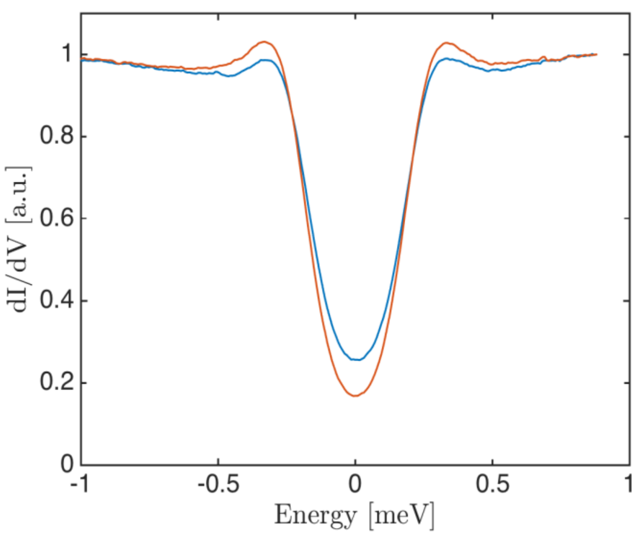

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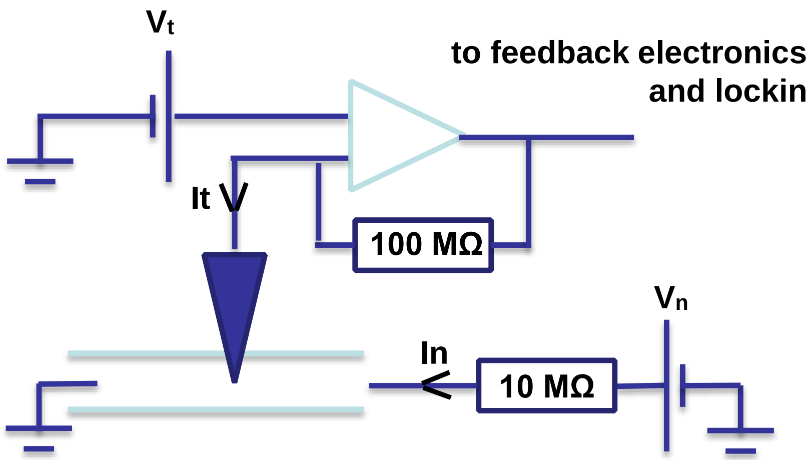

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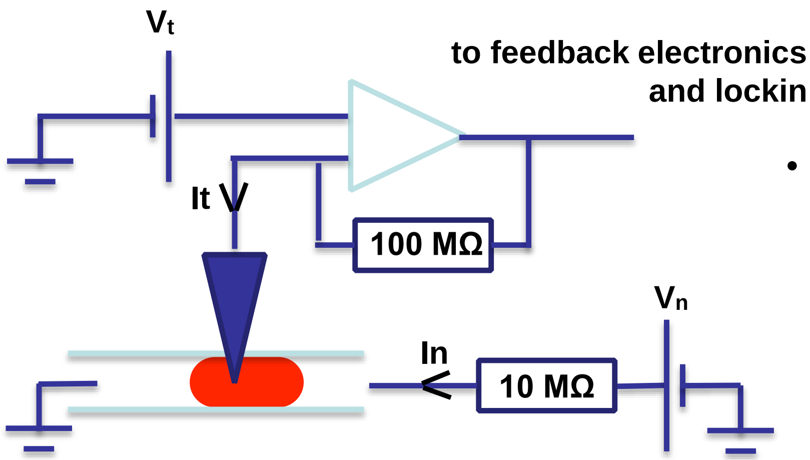
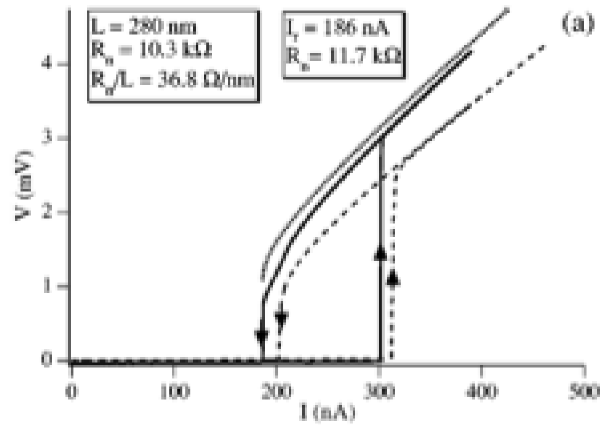
Spectroscopy in a non-equilibrium state

TiN



- Our wire
  - $I_c \sim 1.2\ \mu A$
  - $I_r \sim 35$ nA

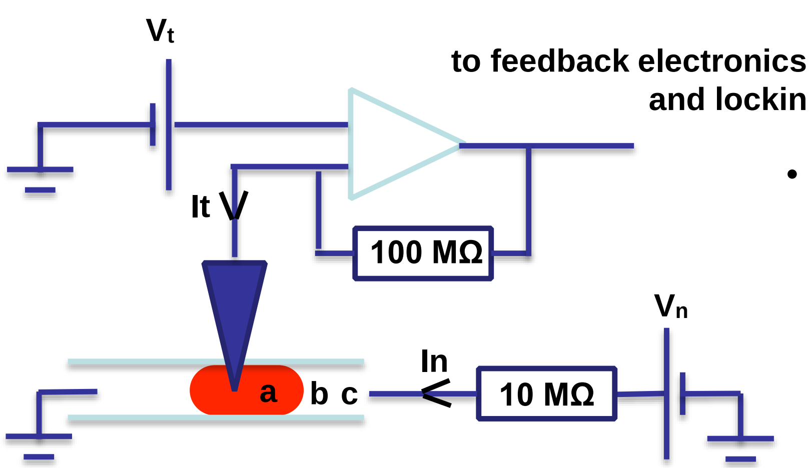


W.J. Skocpol et al., *J. Appl. Phys.* (1974)
Tinkham *et al., Phys. Rev. B* (2003)

E. Driessen et al., ***unpublished***

Spectroscopy in a non-equilibrium state

TiN



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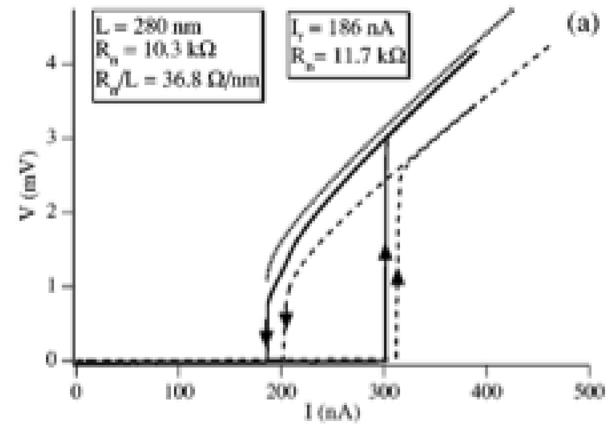
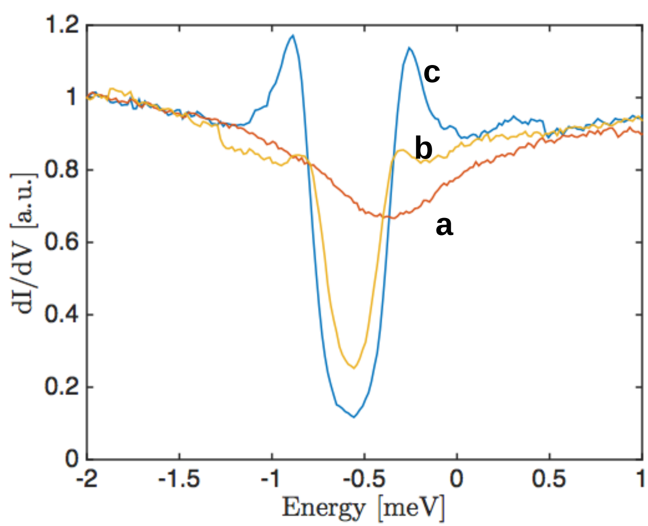
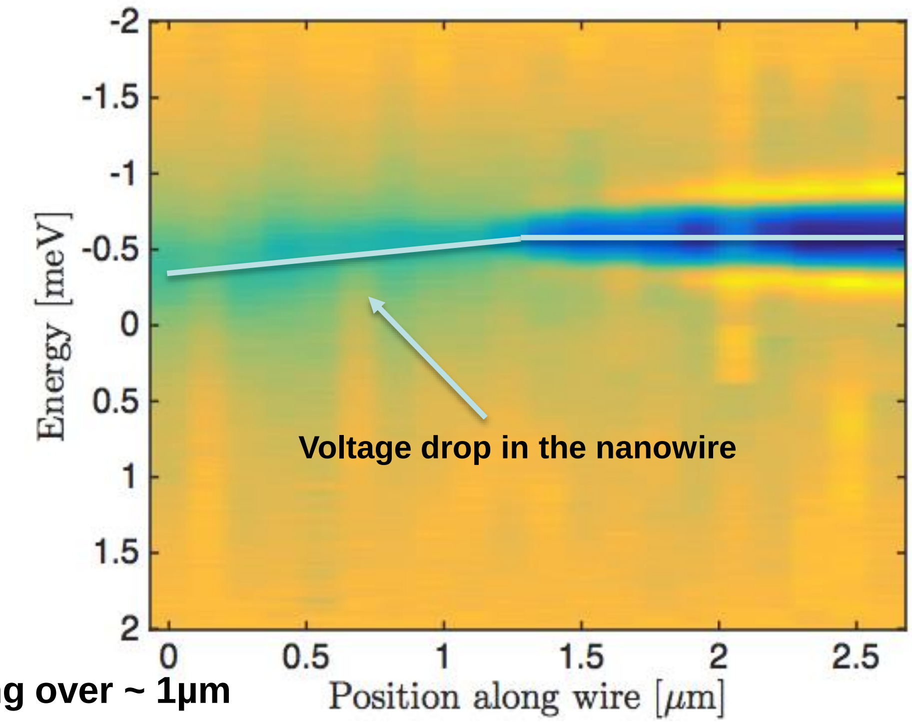


W.J. Skocpol et al., *J. Appl. Phys.* (1974)
Tinkham *et al., Phys. Rev. B* (2003)



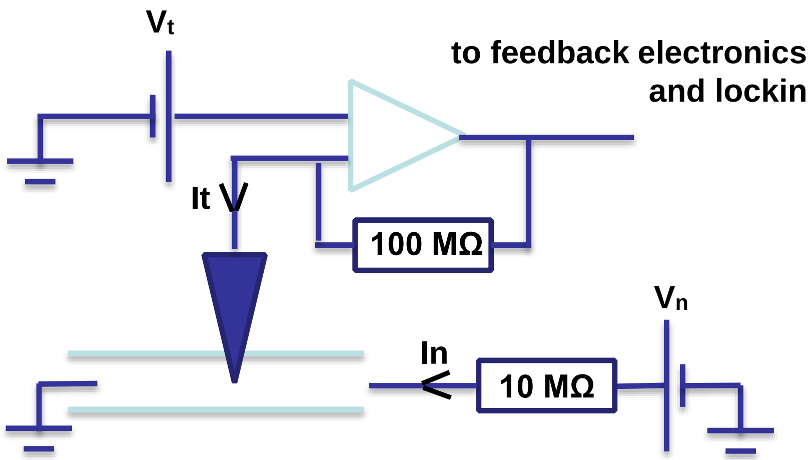


- Thermal healing over ~ 1µm
- I_{wire} = 40 nA

E. Driessen et al., *unpublished*

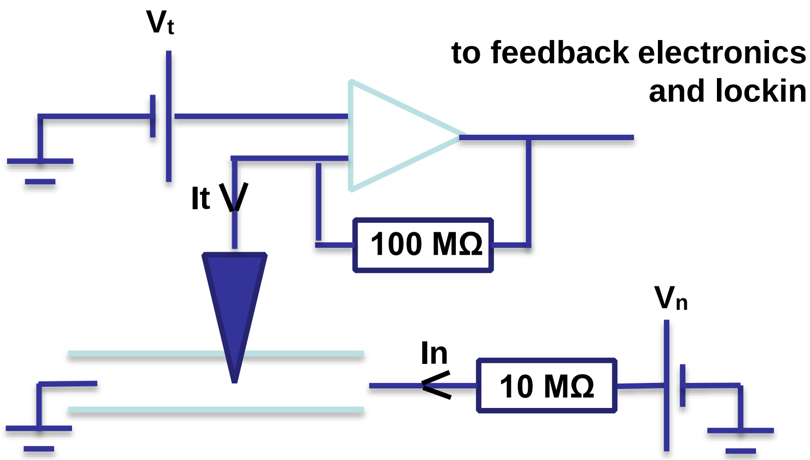
Critical current microscopy

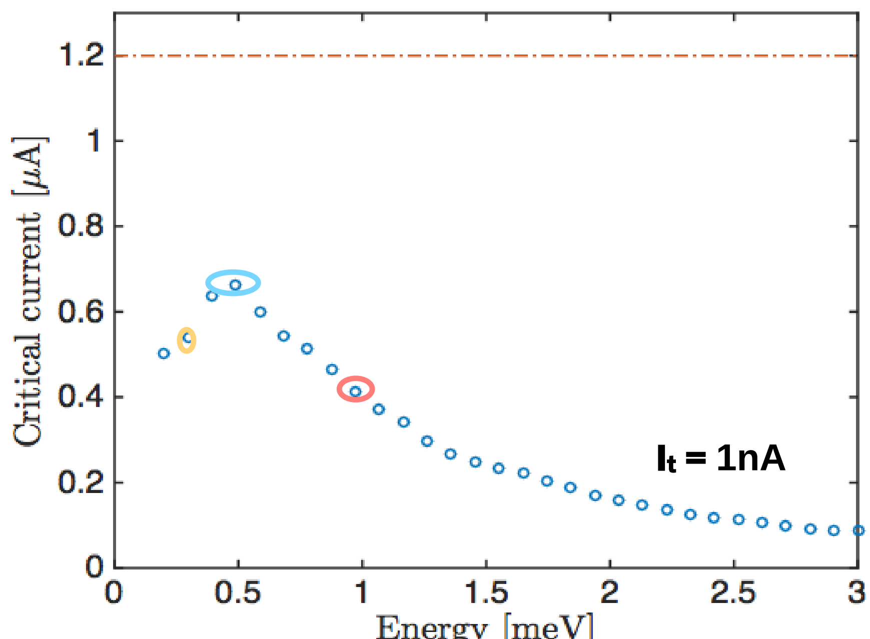
TiN

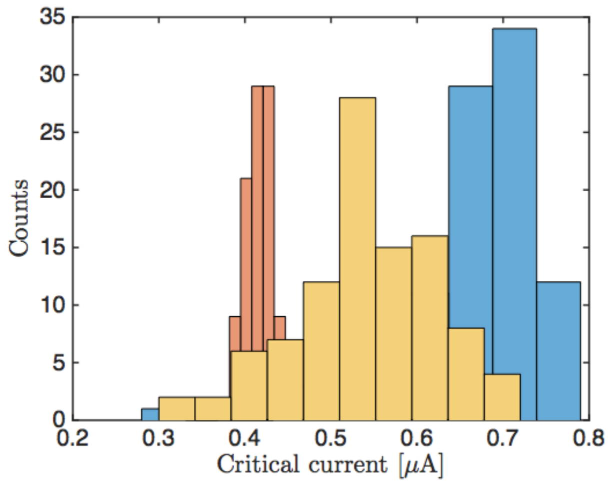


Critical current microscopy

TiN



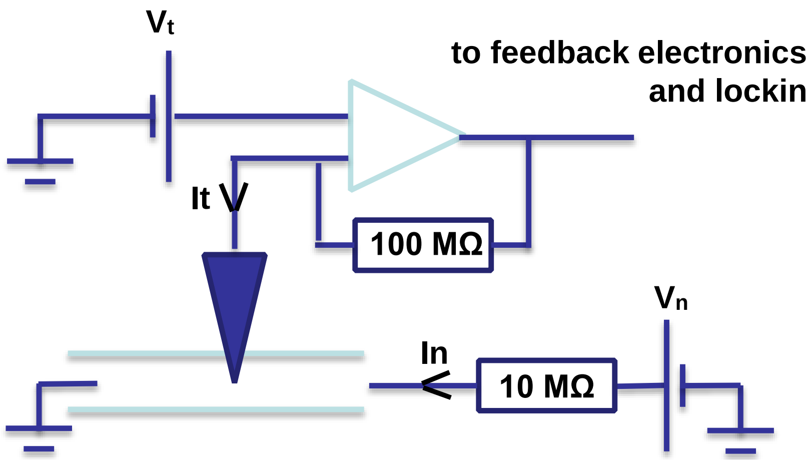


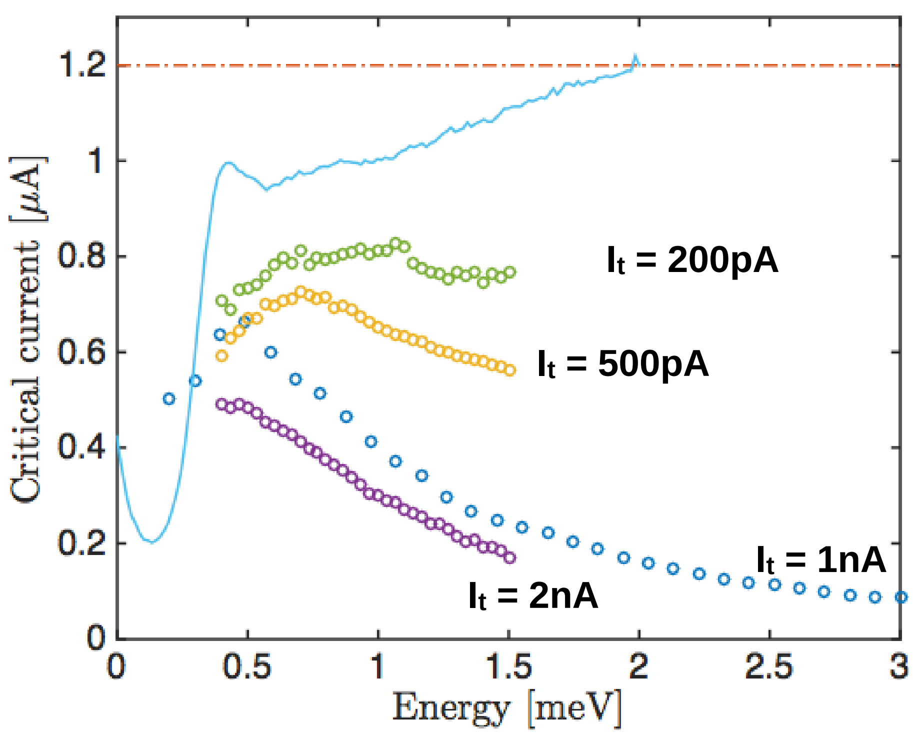


E. Driessen et al., *unpublished*

TiN

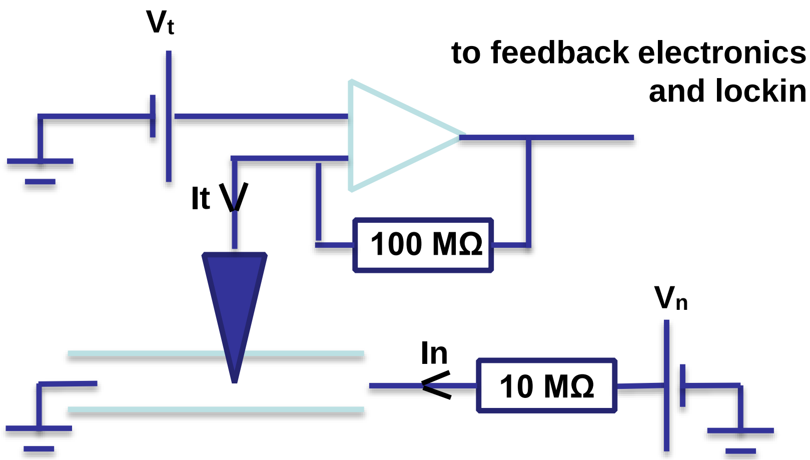
Long live time of quasiparticles close to the gap

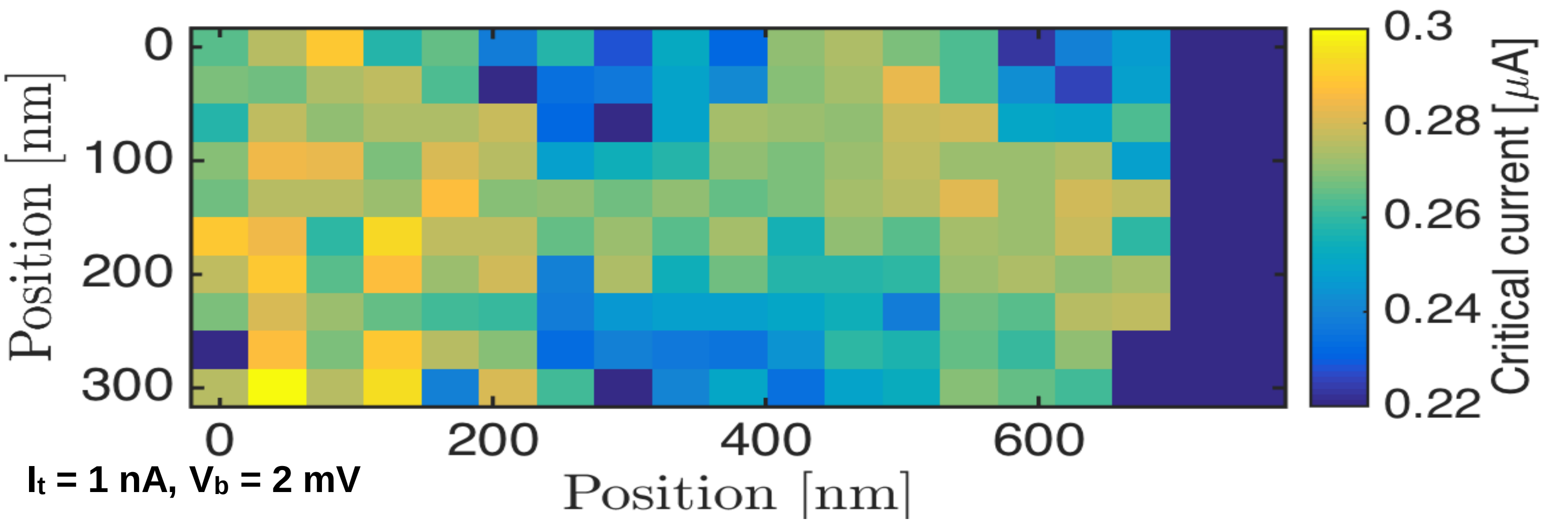




TiN

Map of local non-equilibrium





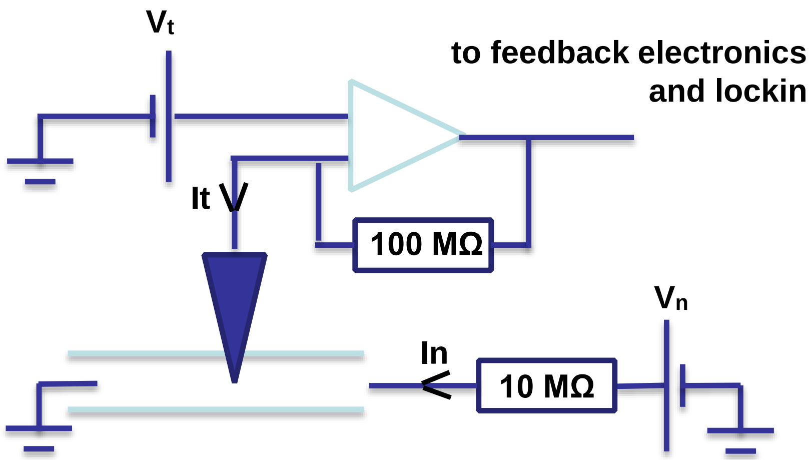
I_t = 1 nA, V_b = 2 mV

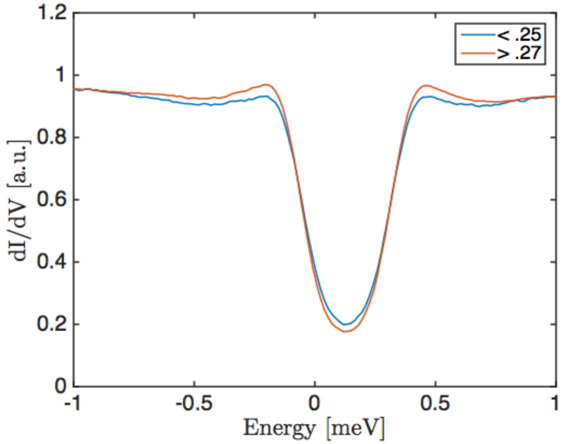
E. Driessen et al., *unpublished*

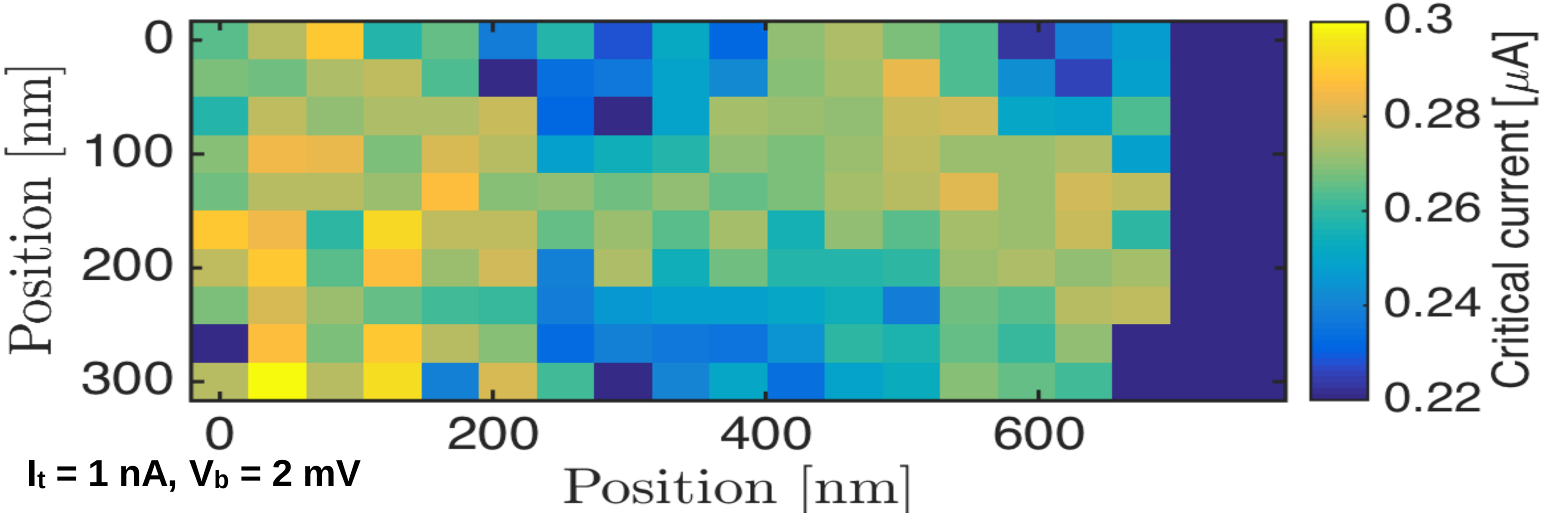
Critical current microscopy

TiN

Map of local non-equilibrium







I_t = 1 nA, V_b = 2 mV

E. Driessen et al., *unpublished*

Critical current microscopy

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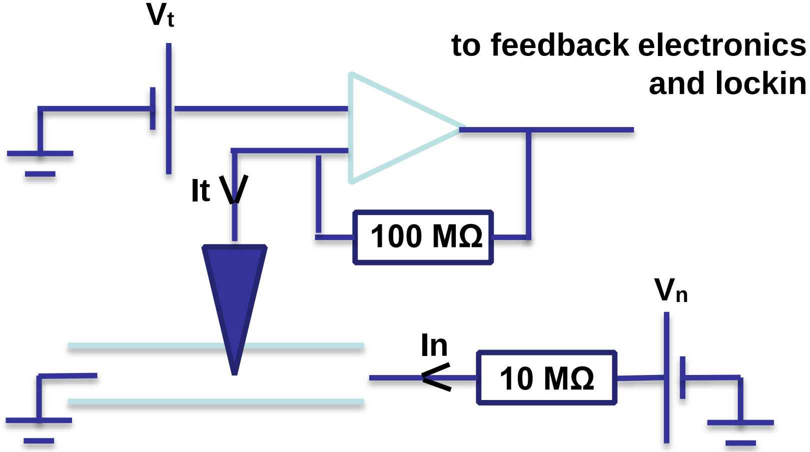
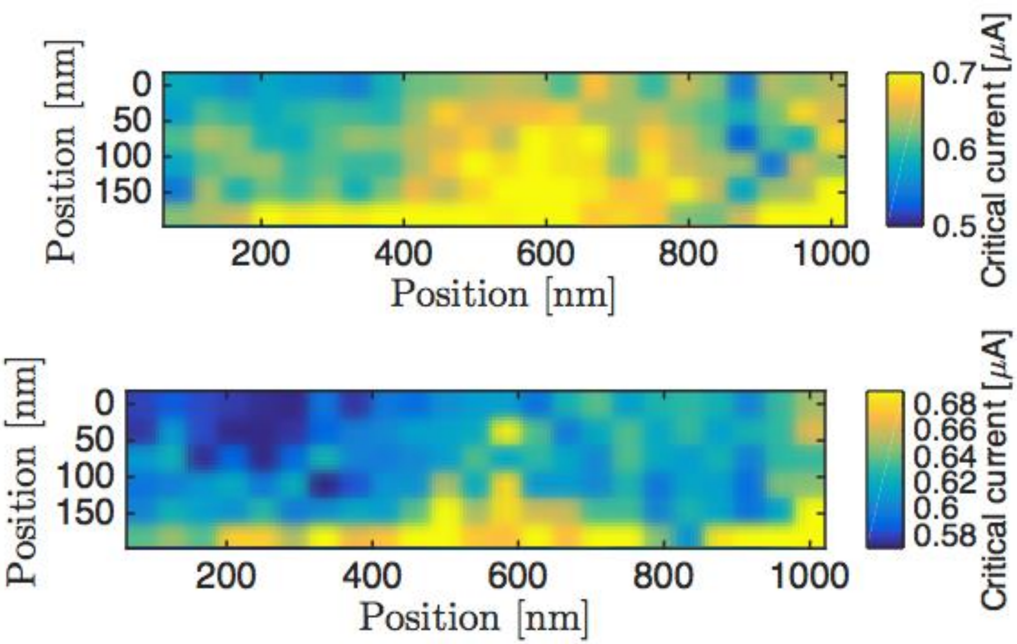
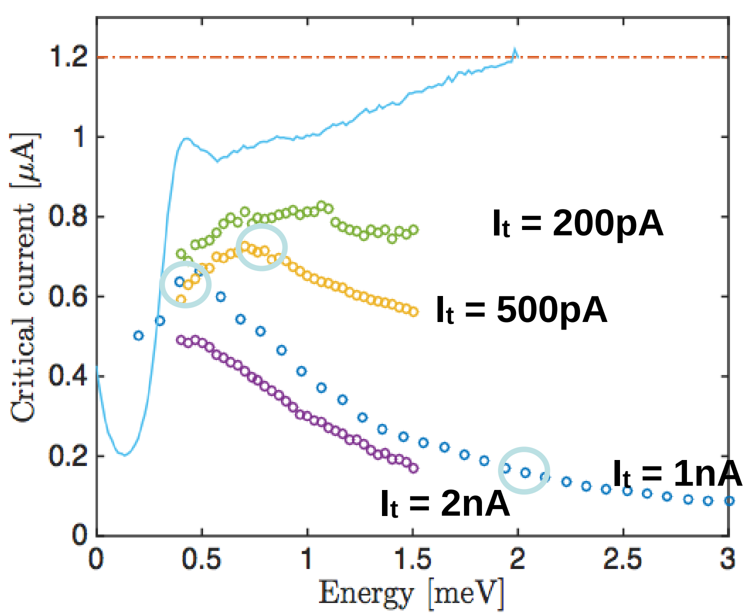
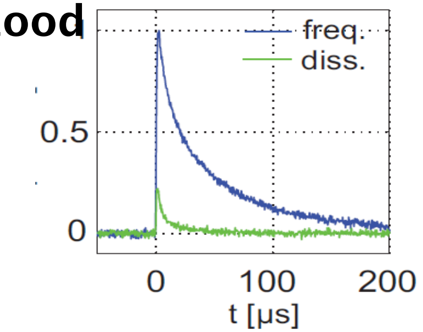




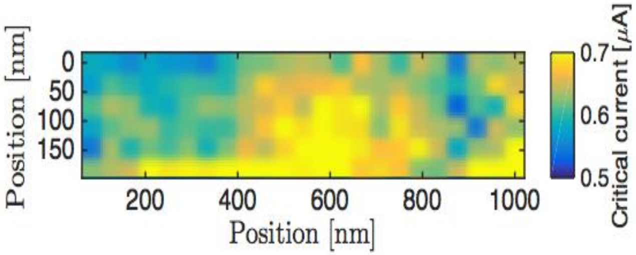


Conclusion

- **Disordered superconductors are promising materials for photon detector however quasiparticle dynamic must be understood**



- **Critical current microscopy is a powerful tool in order to probe out-of-equilibrium superconductivity**



- **Outlook : Determining the best materials for MKIDS**