NANO LETTERS
LETTER
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Spin Polarization Measurement of Homogeneously Doped $Fe_{1-x}Co_xSi$ Nanowires by Andreev Reflection Spectroscopy

John P. DeGrave,[†] Andrew L. Schmitt,[†] Rachel S. Selinsky,[†] Jeremy M. Higgins,[†] David J. Keavney,[‡] and Song Jin[*,†]

[†]Department of Chemistry, University of Wisconsin—Madison, 1101 University Avenue, Madison, Wisconsin 53706, United States
[‡]Advanced Photon Source, Argonne National Laboratory, 9700 S. Cass Avenue, Argonne, Illinois 60439, United States

Gergő Fülöp

NanoSeminar Journal Club

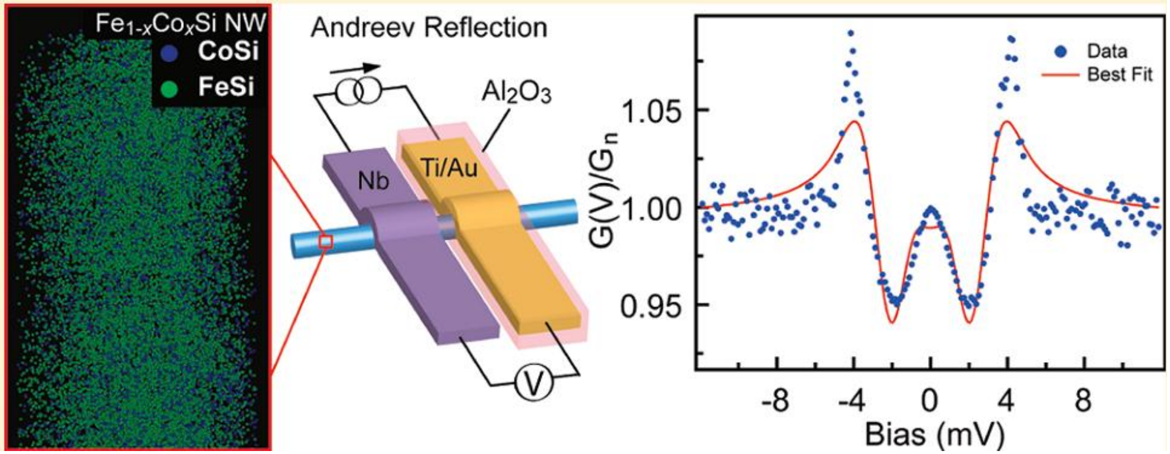
29/09/2011

MŰEGYETEM 1782

Outline

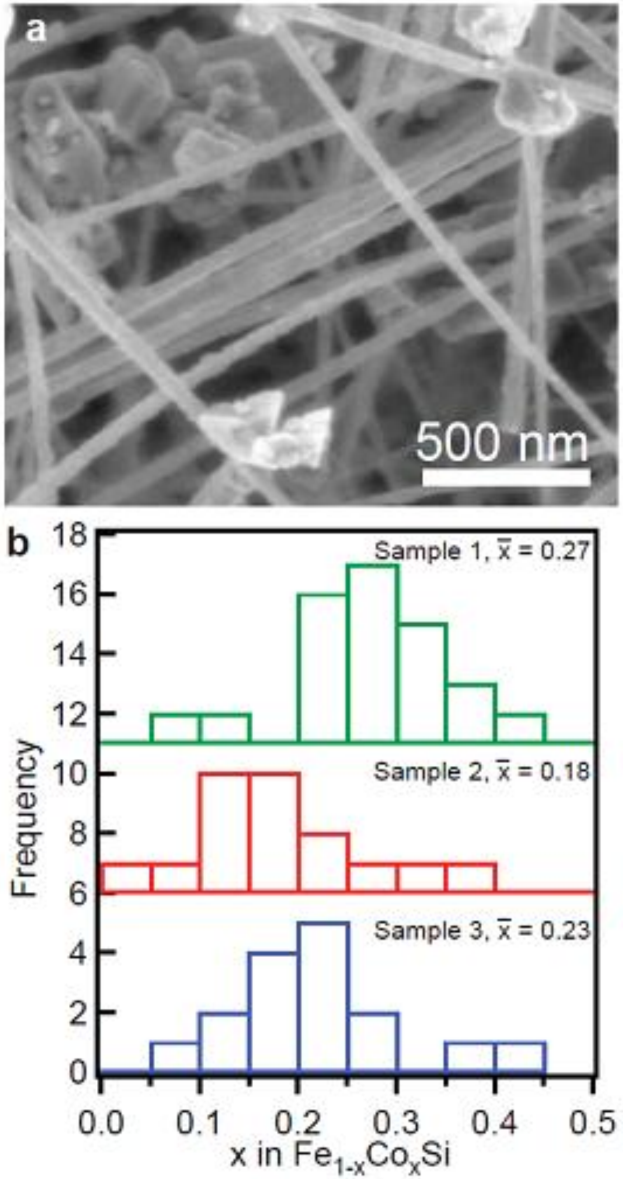
- Nanowire growth
  - Homebuilt CVD system
- Compositional studies, origin of magnetism
  - Energy Dispersive Spectroscopy (EDS)
  - Atom Probe Tomography (APT)
  - X-ray Magnetic Circular Dichroism (XMCD)
- Device fabrication
- Electronic measurements

$$P_s = \frac{(N_\uparrow - N_\downarrow)}{(N_\uparrow + N_\downarrow)}$$



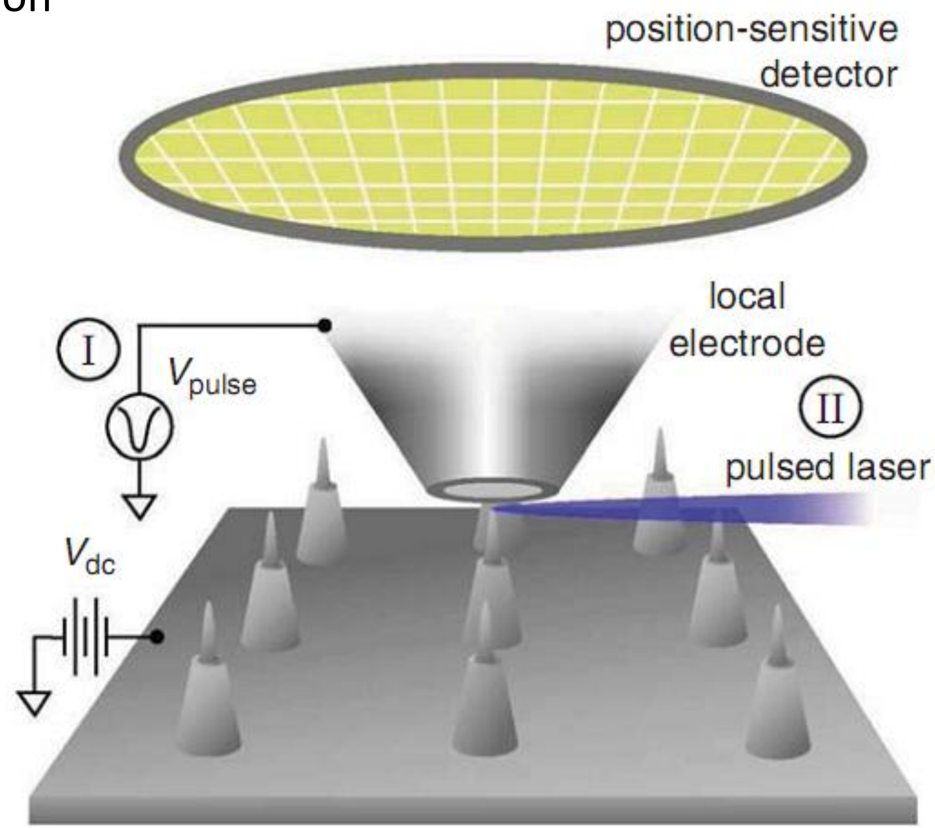
NW growth, EDS

- NW growth
  - 750 °C, 200 torr
  - Precursors:
    - Samples 1, 2: Trans-$Fe(SiCl_3)_2(CO)_2$, $Co(SiCl_3)(CO)_4$
    - Sample 3: Trans-$Fe(SiCl_3)_2(CO)_2$, $CoCl_2$
- EDS
  - determining x (cobalt cc.)
  - $Fe_{1-x}Co_xSi$



Atom Probe Tomography

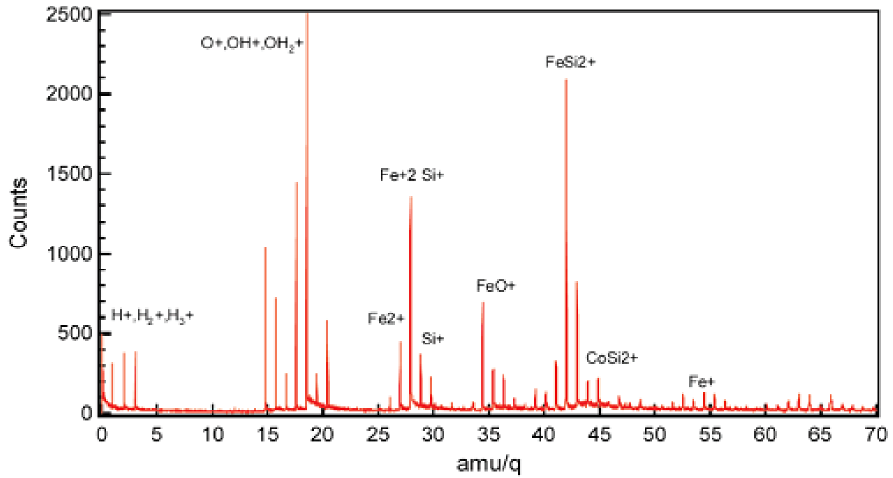
- Principles
  - Field Ion Microscope + Time-of-flight Mass Spectrometer
  - 3D reconstruction with Å resolution
  - elemental mapping

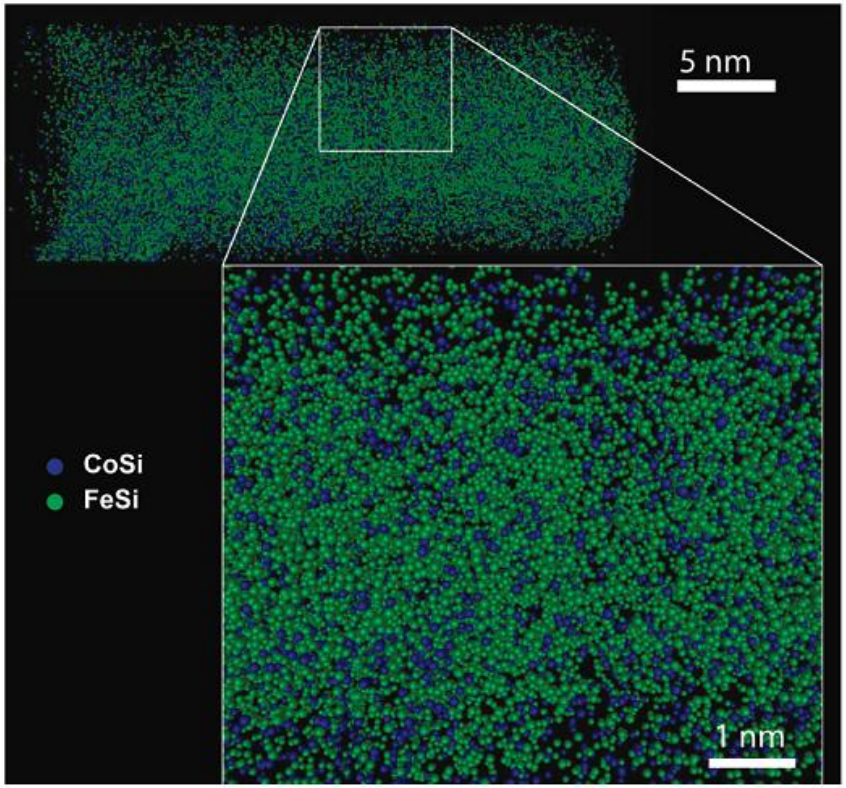


Seidman, D. N.; Stiller, K. MRS Bull. 2009, 34, 717–724.

Atom Probe Tomography

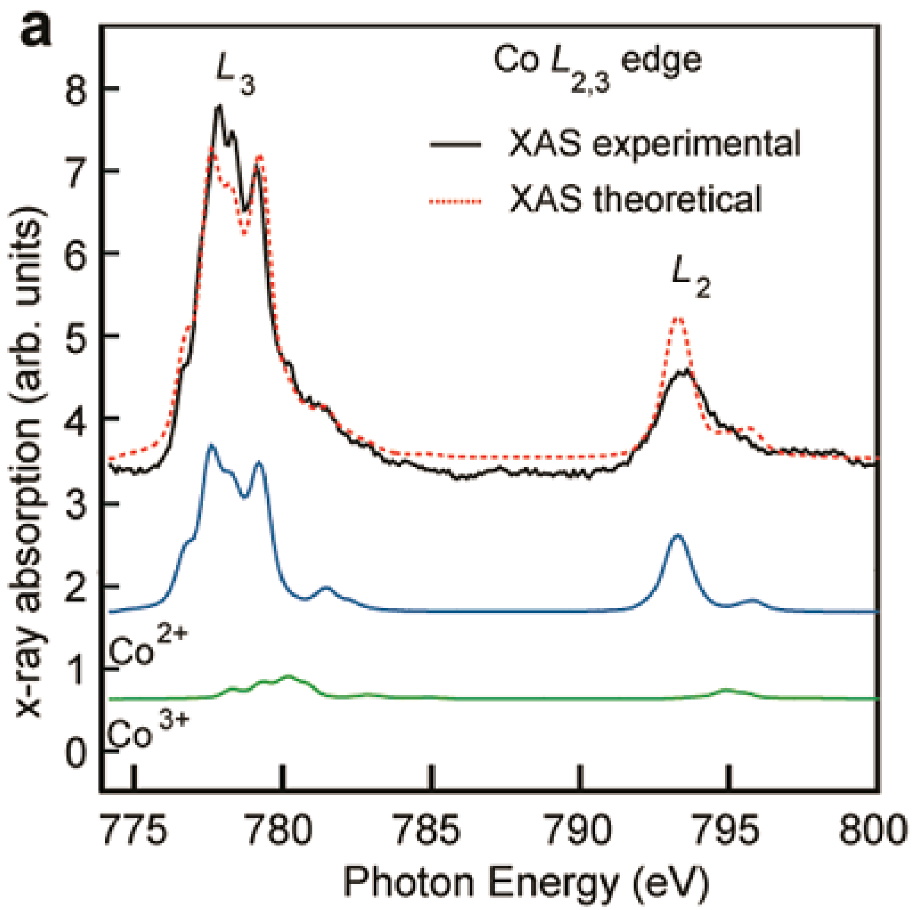
- $Fe_{1-x}Co_xSi$
  - ≈500 000 ions collected
  - the Co is distributed homogeneously in the FeSi lattice





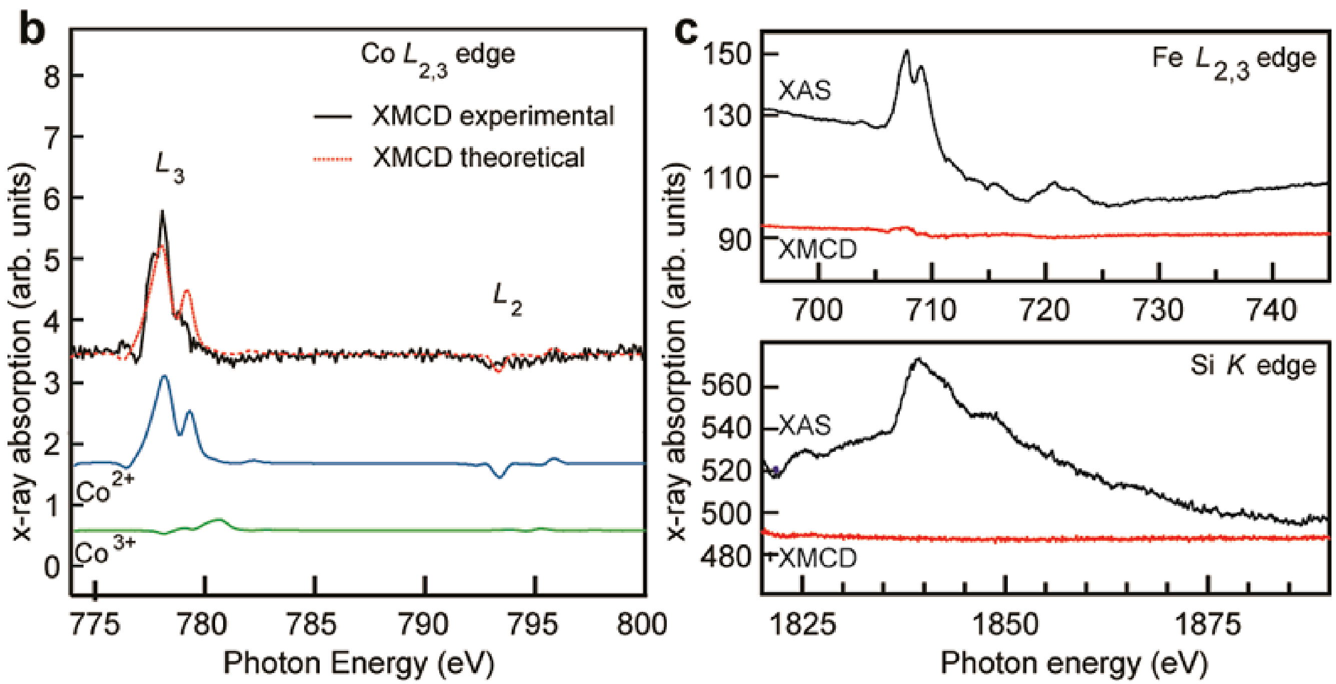
X-ray Circular Magnetic Dichroism

- XAS: X-ray Absorption Spectrum
  - measured by the total electron/fluorescence yield



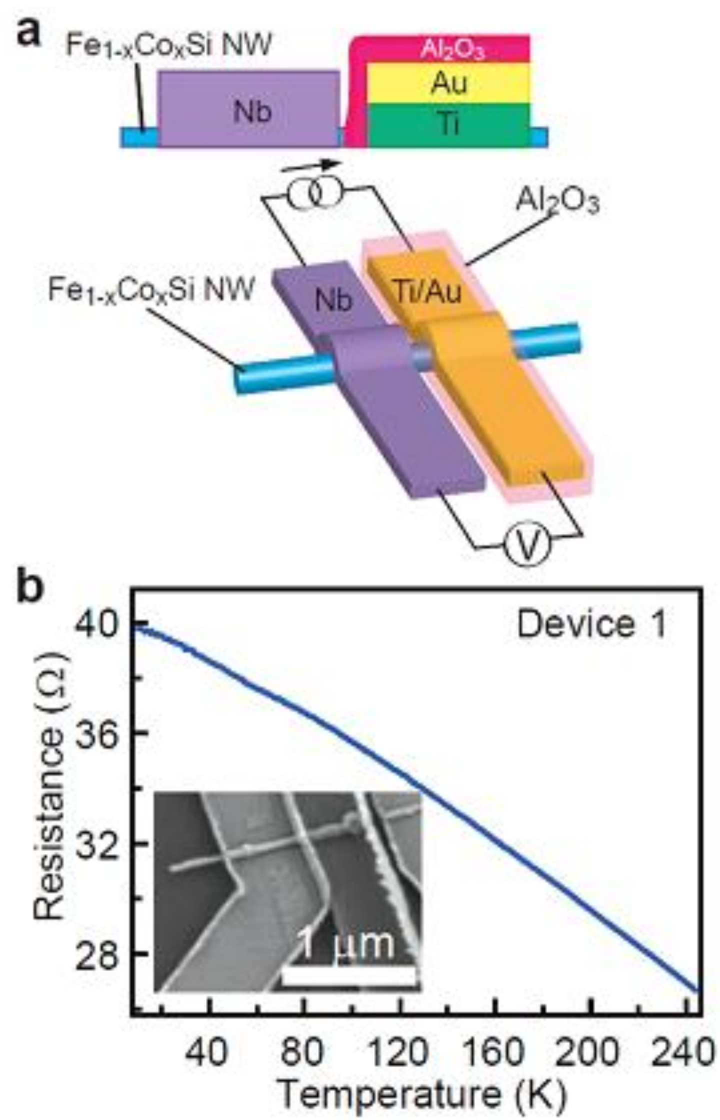
X-ray Circular Magnetic Dichroism

- XAS: X-ray Absorption Spectrum
  - measured by the total electron/fluorescence yield
- XMCD: difference between LCP and RCP XAS signal
  - direct measurement of the spin-dependent DOS
  - synchrotron source (Argonne National Laboratory); T = 6 K, B = 2 T
  - dominance of Co XMCD signal (+ small Fe signal, unobservable Si signal)



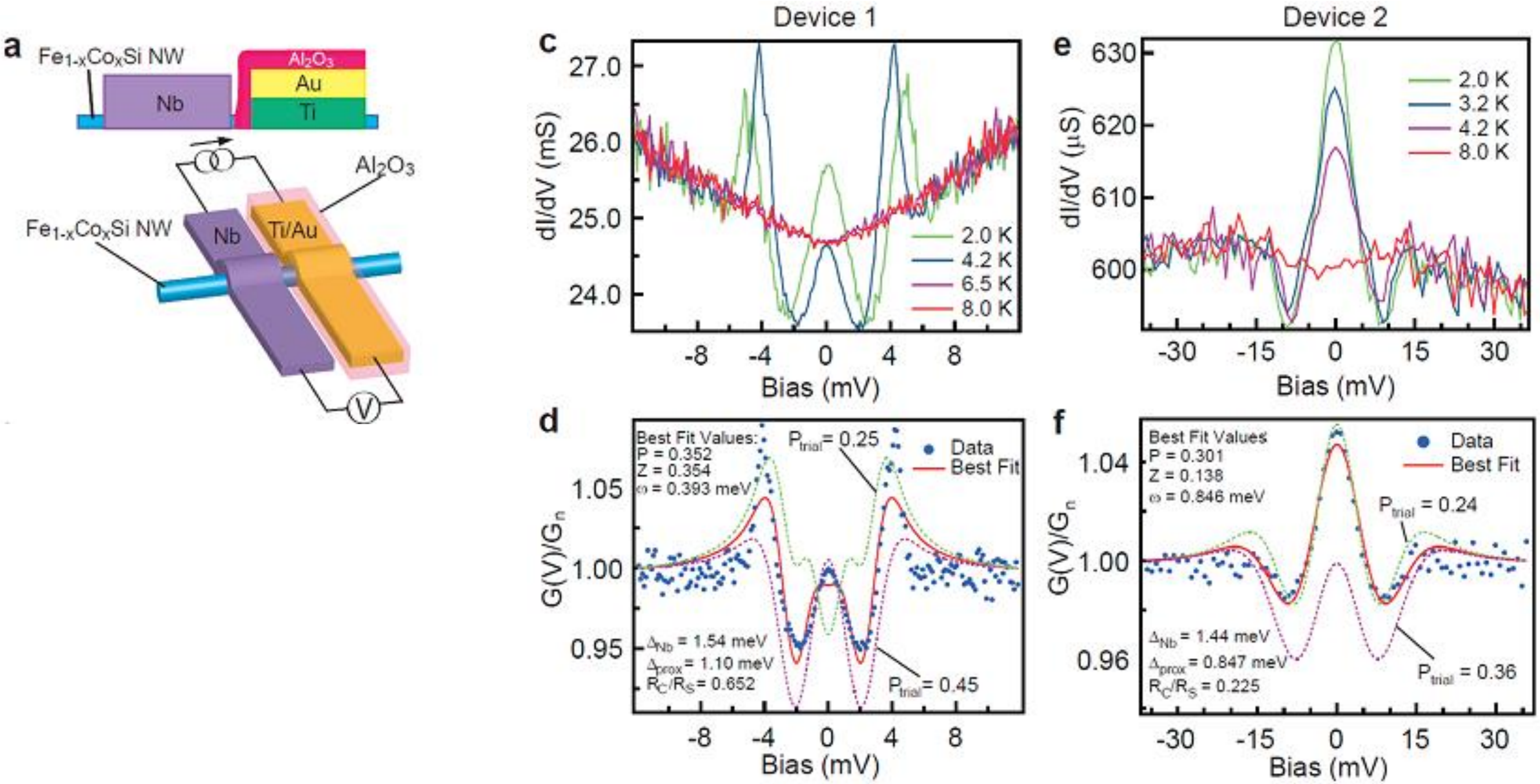
- Contact electrodes:
  - normal electrode: Ti/Au

    + 40 nm Al_2O_3 (to overcome the lithographic misalignment issue)
  - superconducting electrode: Nb
- Short channel: 200 nm



Measurements

- Andreev reflection
  - scattering peaks at $\pm\Delta_{Nb}$ (with finite width due to proximity related effects)
  - symmetric peak near zero bias



- Evaluation
  - extraction of spin polarization: $P_s = \frac{(N_\uparrow - N_\downarrow)}{(N_\uparrow + N_\downarrow)}$

    from peak height: $G(0)/G_n = 2(1 - P_s)$
  - 1D modified Blonder-Tinkham-Klapwijk (BTK) model:

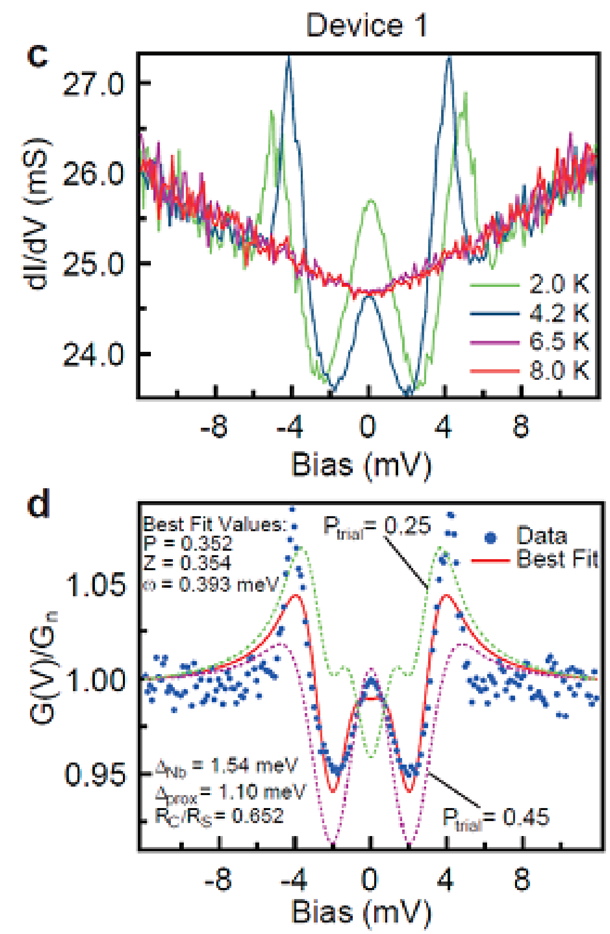
$$G(V) = \int_{-\infty}^{\infty} \frac{df(E-V,T)}{dV}[1 + A(E,Z) - B(E,Z)]dE$$

$$V_{total} = V_{junction} + V_{nanowire}$$

  - A, B: from Strijkers et al.
  - voltage drop, nonideal behaviour

    → additional fitting parameters

Average P_s = 28 % (highest P_s = 35 %)



Thank you for your attention!