Selective and Sensitive Detection of Superconductivity

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① Why is this **important?**

Characterization of the **M**agnetic **F**ield **M**odulated **M**icrowave **S**pectroscopy (**MFMMS**) response of various materials.

Known-Superconductors
$YB_2Cu_3O_{7-\delta}$, $GdBa_2Cu_3O_x$, Nb, MgB_2, La_2C_{3-x} and $K_{0.8}(FeSe)_2$.

Non Superconductors
Ferromagnetic (**Ni, Py**) thin film
Metallic thin films
MFMMS across phase transitions
• FeF_2 (Antiferro-Paramagnetic, $T_N \sim 80K$)
• Metal-Insulator transition materials (V_2O_3 thin film, $T_{MI} \sim 150K$)
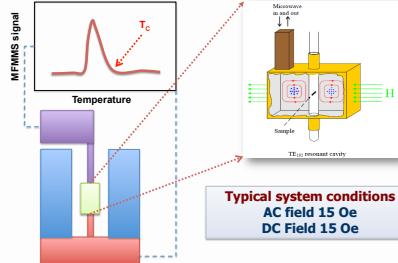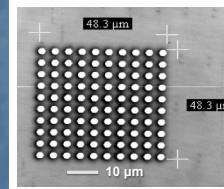
② How does this **apparatus** work?

X-band: 9.4 GHz
Temp. Resolution 0.05K
Temp. range 4.2K to 300 K
Sensitivity 10^{-12} cm³

Typical system conditions
AC field 15 Oe
DC Field 15 Oe
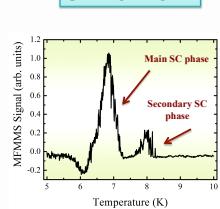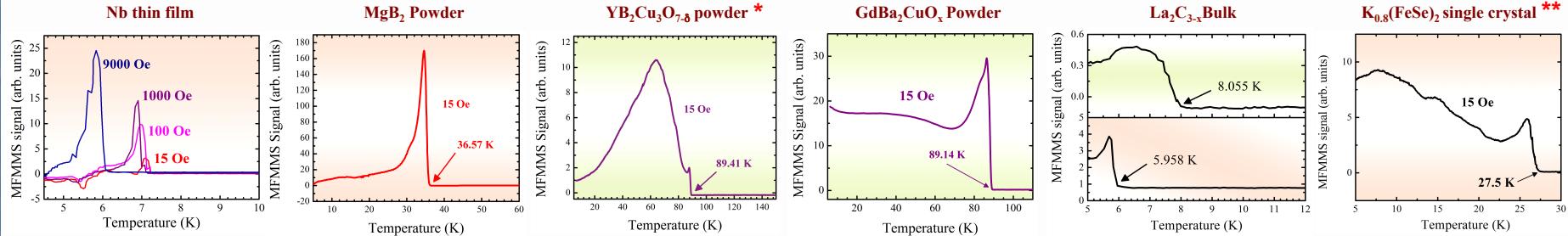
③ High sensitivity

Nb Dots on Silicon

Nb Volume
3×10^{-11} cm³

Main SC phase
Secondary SC phase
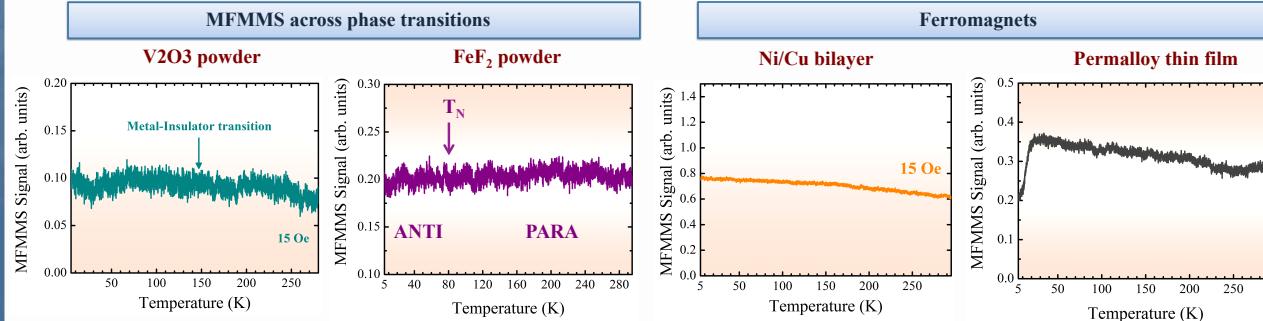
④ MFMMS signal from Known Superconductors

Nb thin film — 9000 Oe, 1000 Oe, 100 Oe, 15 Oe

MgB_2 Powder — 15 Oe, 36.57 K

$YB_2Cu_3O_{7-\delta}$ powder * — 15 Oe, 89.41 K

$GdBa_2CuO_x$ Powder — 15 Oe, 89.14 K

La_2C_{3-x} Bulk — 8.055 K, 5.958 K

$K_{0.8}(FeSe)_2$ single crystal ** — 15 Oe, 27.5 K

⑤ MFMMS Signal from Non-superconductors

MFMMS across phase transitions

V2O3 powder — Metal-Insulator transition, 15 Oe

FeF_2 powder — T_N, ANTI, PARA

Ferromagnets

Ni/Cu bilayer — 15 Oe

Permalloy thin film

⑥ Conclusions

• Selectivity and High sensitivity to magnetic-dependent surface impedance.
• Detection of SC in non-homogenous samples with multiple transitions.
• No contacts on sample.

Future work

• Quantitative analysis of the MFMMS signal for SC and non-SC materials.

* Collaboration with MURI (Stanford and UC Davis)
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