Microwave Characterization of 122-Pnictides by a Superconducting Niobium Cavity

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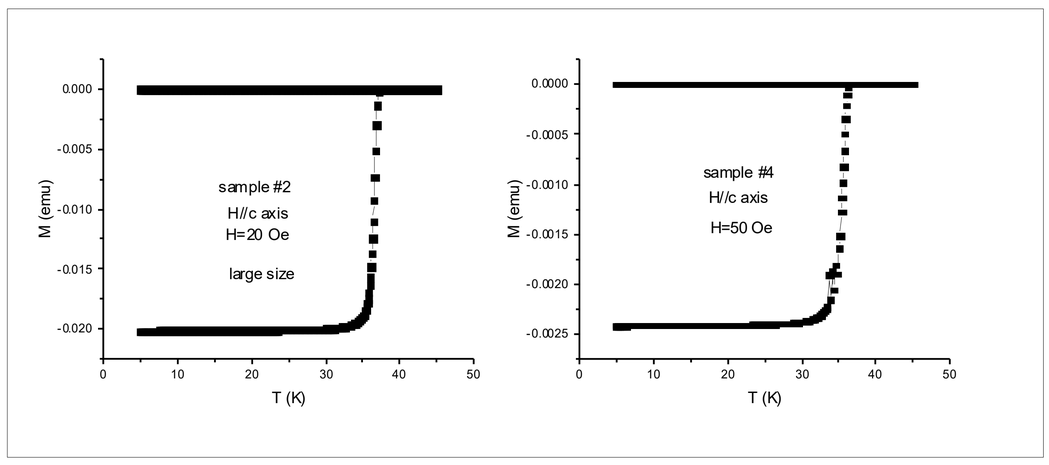
We present first results of our microwave measurements of $Ba_{1-x}K_xFe_2As_2$ (with x = 0.34) single-crystal pnictides, using a cylindrical superconducting niobium microwave cavity, working at approx. 26.2 GHz in the TE_{011}-mode. The measured samples, after initial magneto-optic tests of their uniformity, are cut and glued on a sapphire rod, whose temperature can be independently controlled between 5 K and 40 K.

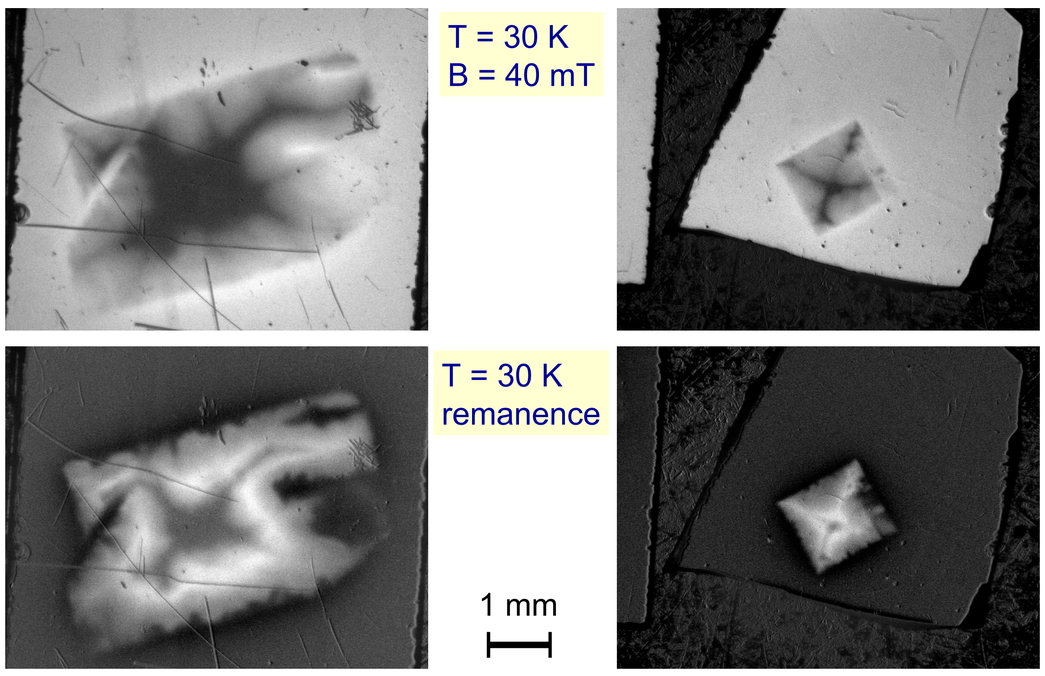
Microwave measurements are performed by a vector network analyzer in the reflection mode, i.e. the S_{11} component of the complex scattering matrix S is measured. The loaded Q factor and the shift of the resonance position are measured during a temperature sweep, followed by calculating of the unloaded Q_0 factor and the resonance frequency f_L by means of the Kajfez procedure [1]. The values of the superconducting penetration depth change λ_L and of the surface resistance R_s are calculated approximating the single crystal sample by a flat cylindrical rod of appropriate size, based on a procedure described by Maier and Slater [2].

Samples

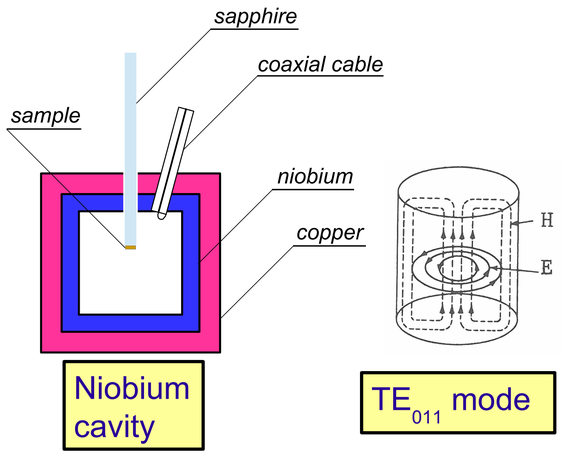
Single crystals of $(Ba_{1-x}K_x)Fe_2As_2$, with x = 0.34, were synthesized at Ameslab using the high-temperature FeAs flux method.

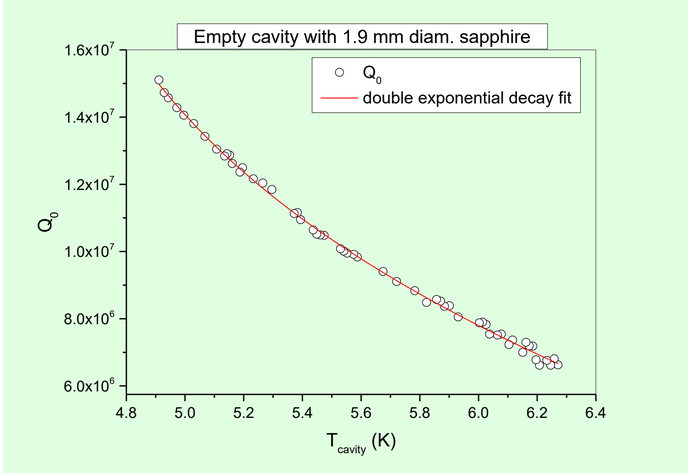


Magnetization curves for samples RS 2 (left) and RS 4 (right).

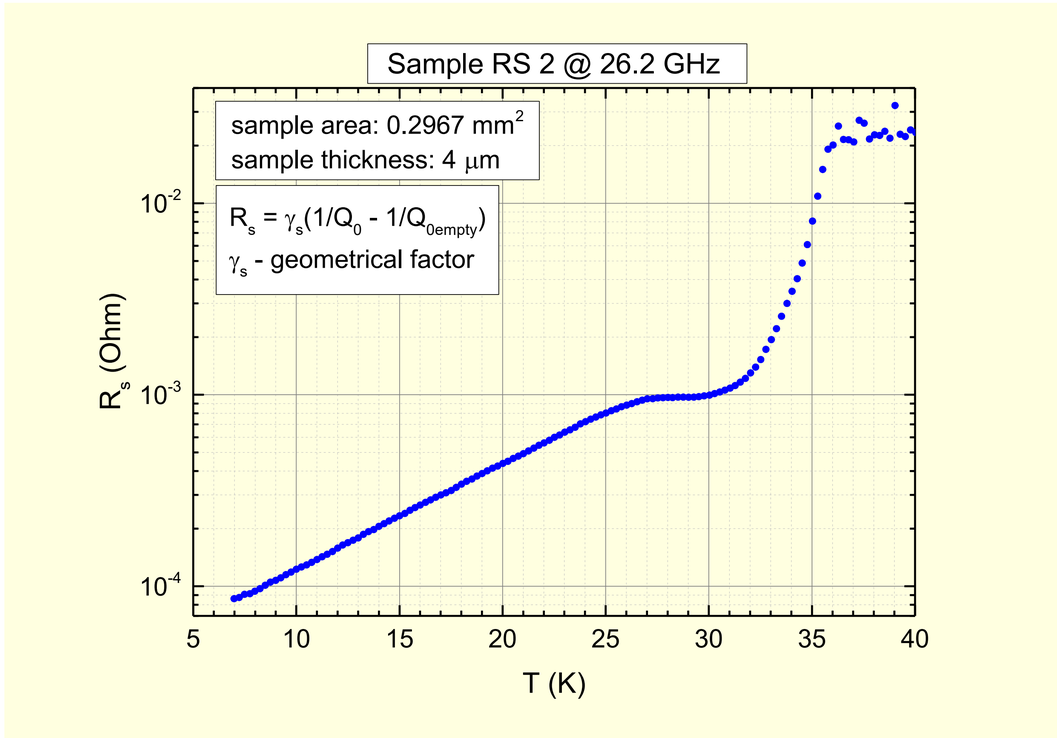


Magnetooptic images for samples RS 2 (left) and RS 4 (right).

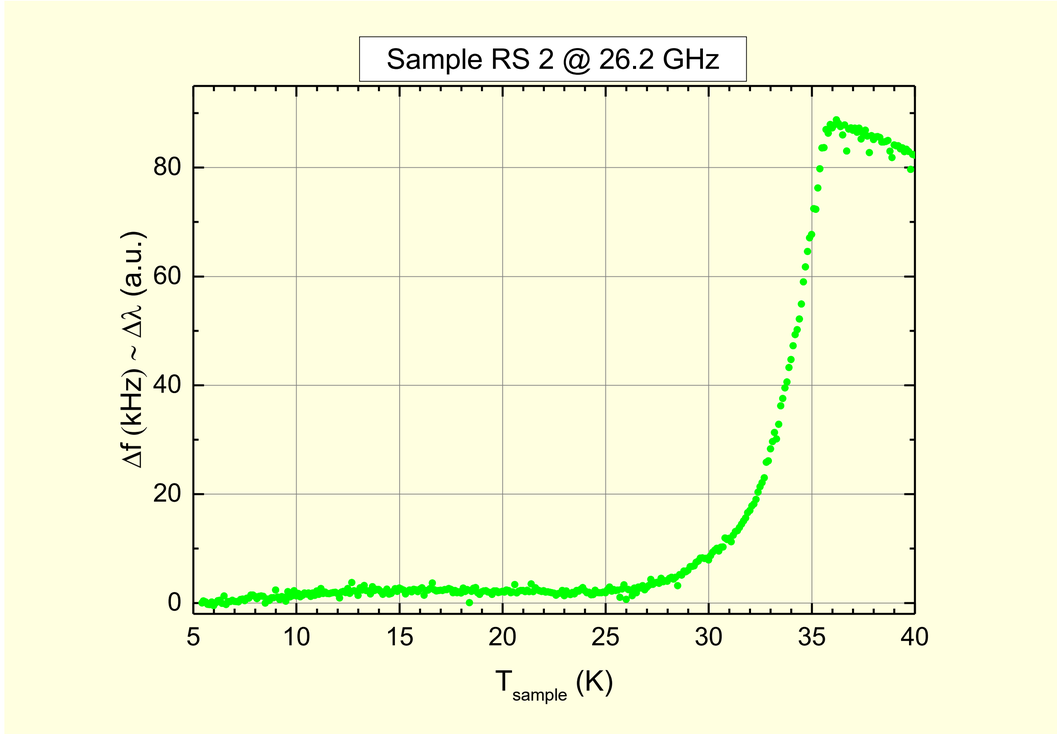




Temperature dependence of the Q_0 factor of the empty cavity.



Temperature dependence of surface resistance of a small RS 2 sample.



Temperature dependence of the penetration depth change of a small RS 2 sample.

Microwave measurements

Smaller (uniform) samples were cut and glued by nonadecane ($C_{19}H_{40}$) on a sapphire rod with a diameter of 1.9 mm protruding into the Nb cavity about 5 mm.

The 26.2 GHz niobium cylindrical cavity was placed in vacuum, cooled only by the thermal conductivity of the surrounding copper parts, in contact with liquid He. A pressure stabilization device was added to He recovery system, to prevent pressure drops caused by periodic evacuation of the gas-holder close to the He liquefier.

Microwave measurements were carried out using a Vector Network Analyzer (VNA), model N5222A, manufactured by Keysight Instruments. A microwave power of 0 dBm was applied, the sweep frequency width was 2 MHz around an appropriate center frequency between 26.1 and 26.5 GHz. The intermediate frequency of the sweep was set to 2 kHz.

Both surface resistance and penetration depth changes were evaluated using perturbation theory, based on a paper by Maier and Slater, who obtained analytical solutions (with perturbation theory) for a conducting sample having the shape of a sphere, needle or an ellipsoidal disk placed in a cylindrical microwave cavity. Our samples were approximated by flat ellipsoidal disks.

References

[1] D. Kajfez, *Q-factor* (Vector Fields, Oxford, MS, USA, 1994).
[2] L.C. Maier, Jr. and J.C. Slater, *J. Appl. Phys.* **23**, 68 (1952).

Conclusions

The performance of a high Q_0 niobium cavity with a Q_0 factor of 1.5×10^7 at 4.9 K was demonstrated. It can be applied for the measurements of surface resistance and relative penetration depth changes of small crystals above 5 K.

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