THERMAL MAPPING OF SRF CAVITIES BY SECOND SOUND DETECTION WITH TRANSITION EDGE SENSORS AND OSCILLATING SUPERLEAK TRANSDUCERS

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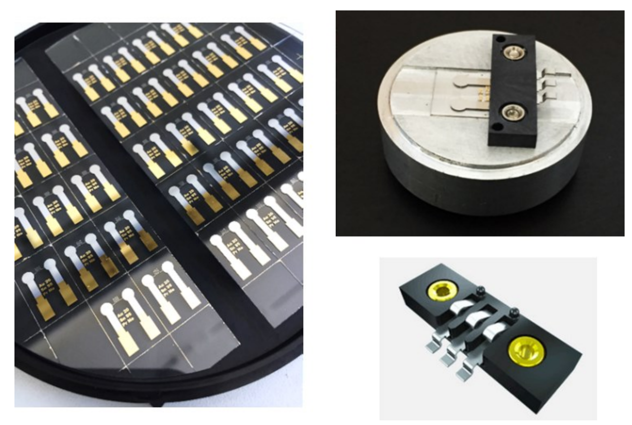
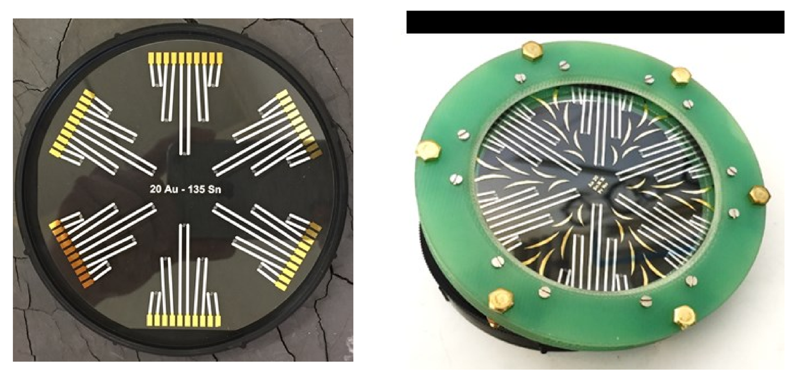
Abstract

The SRF cavity testing facilities at CERN include four vertical cryostat stations in SM18 and a cryostat for small cavities in the Cryolab. A large variety of structures are tested: Nb thin film for HIE-Isolde and LHC, bulk Nb crab for HiLumi, 704MHz 5-cell high-gradient.
To cope with different shapes and small series tests, thermal mapping diagnostics is performed via second sound in superfluid helium.
Transition Edge Sensors (TES) have been developed as miniature resistors of thin-film superconducting alloys, micro-produced on insulating wafers. Optimization of design, fabrication process and composition was ac-companied by qualification in a calibration cryostat. Reproducibility, stability, then intensity, distance and angular dependence of the response were assessed and compared to Oscillating Superleak Transducers (OST). TES were then applied for vertical test of a prototype crab cavity for HiLumi. They allowed localization of a hot spot in a high electric field region, probably a target to field emitted electrons.

Sensor types



Wafer is pre-diced before fabrication, then at the end cut into single sensors.
These are mounted in spring connector for 4-wire cabling, then in disk matching the OST supports.



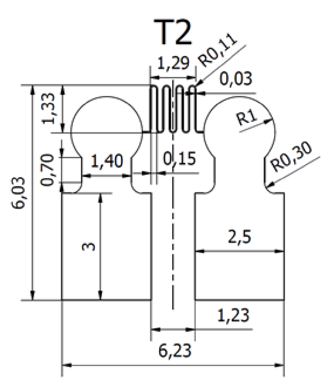
Camera-type wafer with 30 sensors, on composite support for installation in cryostat.

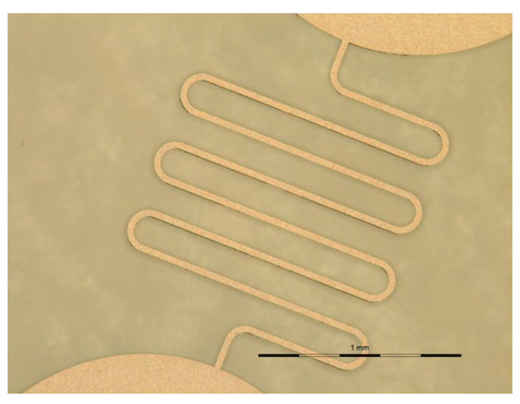
Fabrication

State of the art photolithographic techniques, applied at CMi-EPFL.

1. Lift-off resin & photoresist
2. Laser writing from CAD file
3. Development with solvent
4. Deposition, thickness monitoring
5. Lift-off in removal bath

Process description		Cross-section
Coating positive resist		
LASER Writing Direct		
Developing		
Metal Deposition		
Evaporation	*Sputtering*	
Lift-off with solvents		



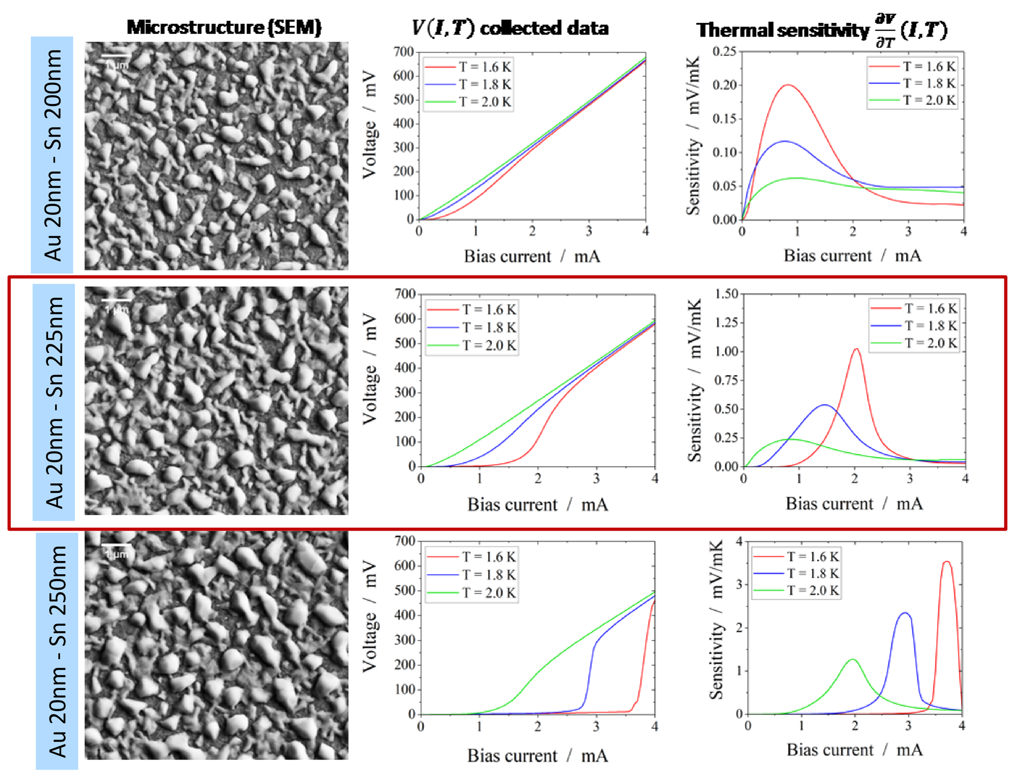


CMi-EPFL: open platform for microfabrication, at Ecole Polytechnique Federale de Lausanne
https://cmi.epfl.ch/

Optimization

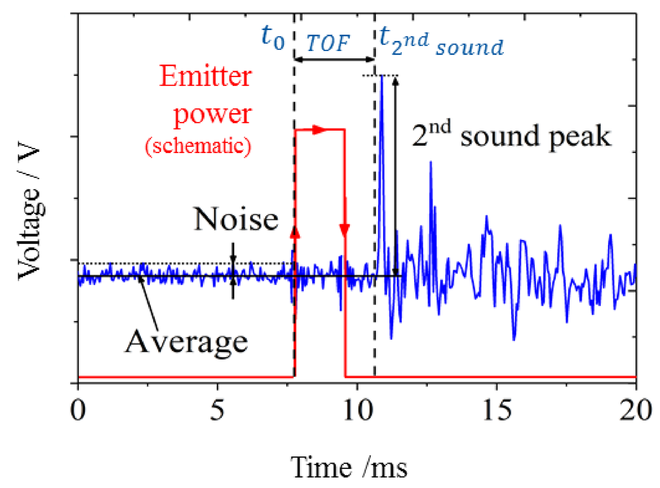
Inhomogeneous thin film:
Sn-rich islets on Sn-poor matrix.

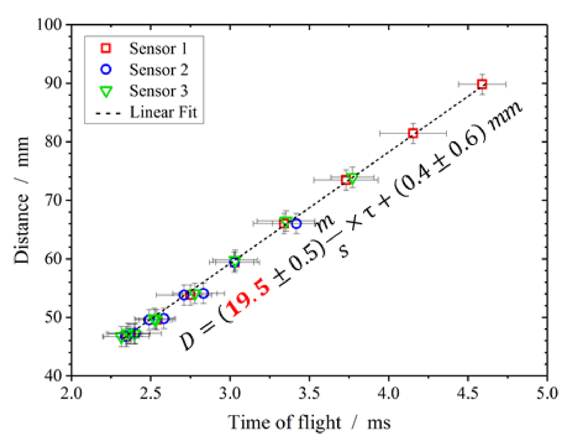
Best result:
strong sensitivity and widest T range



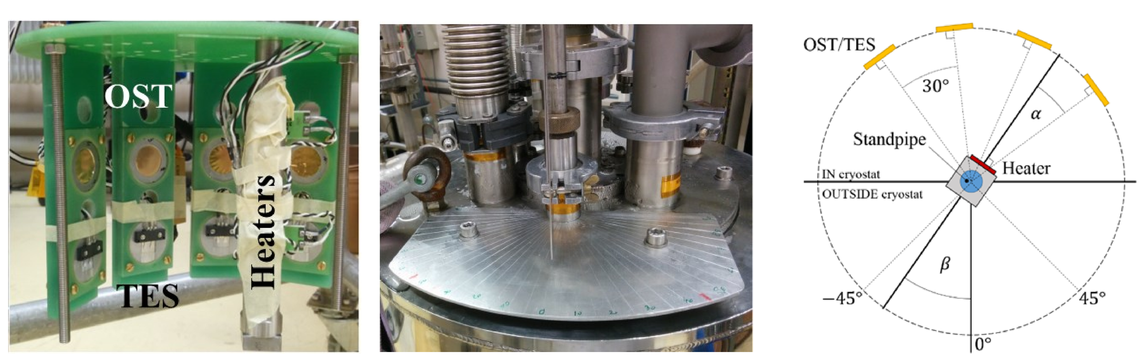
- Transition behaviour sensitive to Sn content
- SC behaviour determined by inter-island distance
- Thermal history of the thin film is crucial: strong interdiffusion, with relaxation time at room temperature ~ 10hrs

Second sound detection

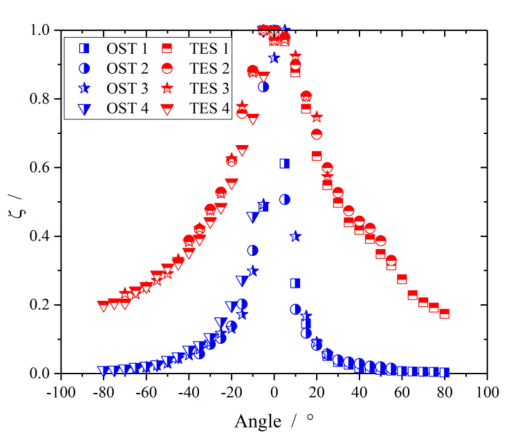




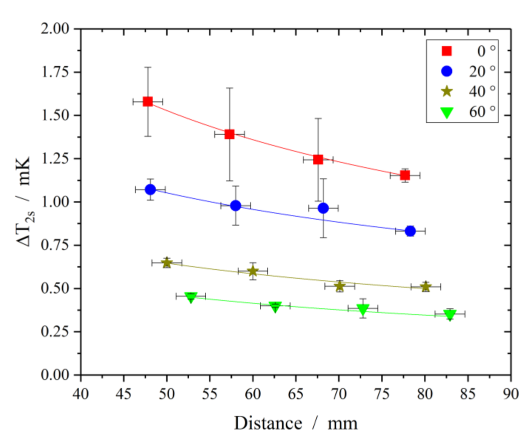
Second sound signal and velocity measurement



Set-up for angular dependence, OST and TES

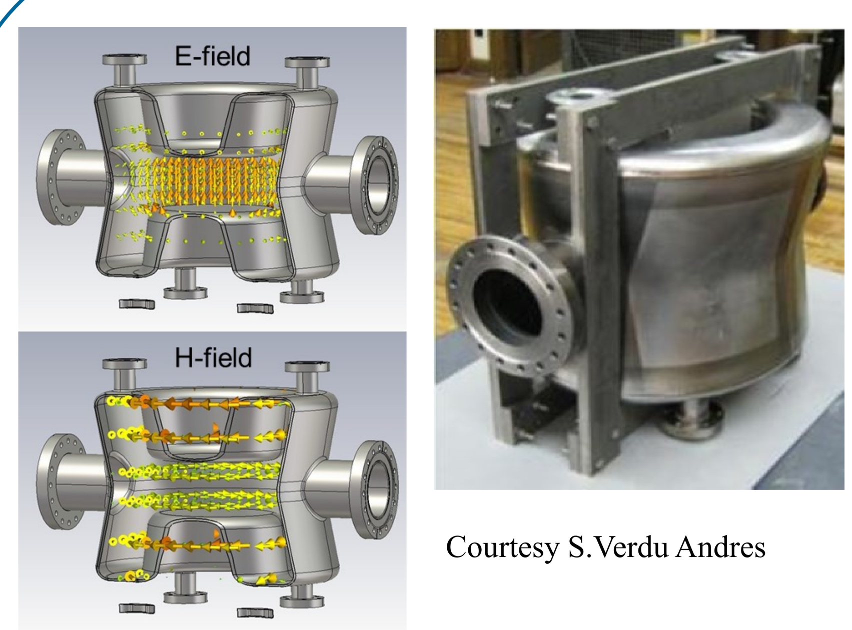


Normalized signal versus angle



Second sound ΔT versus TES distance to heater

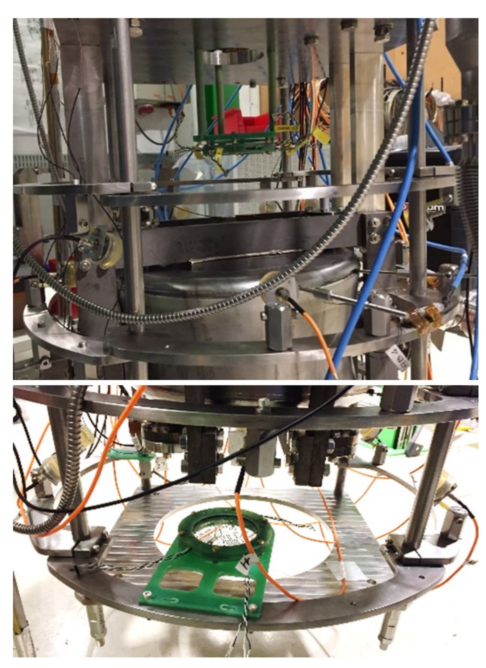
Cavity testing

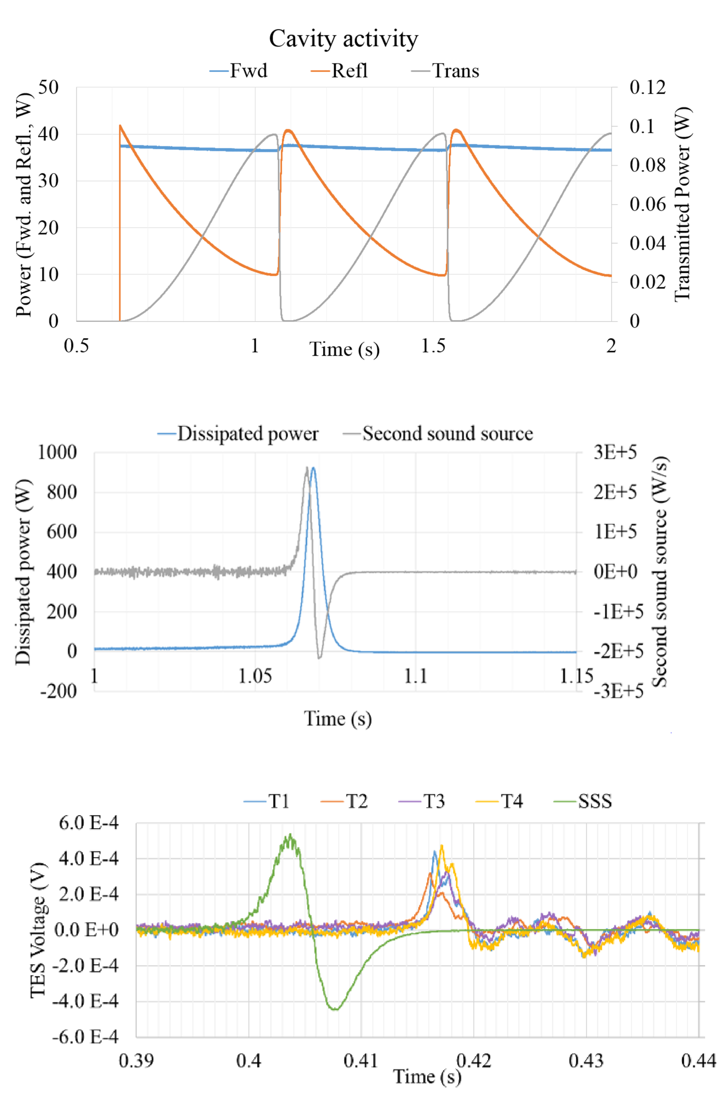


Courtesy S.Verdu Andres

Double-Quarter-Wave crab cavity

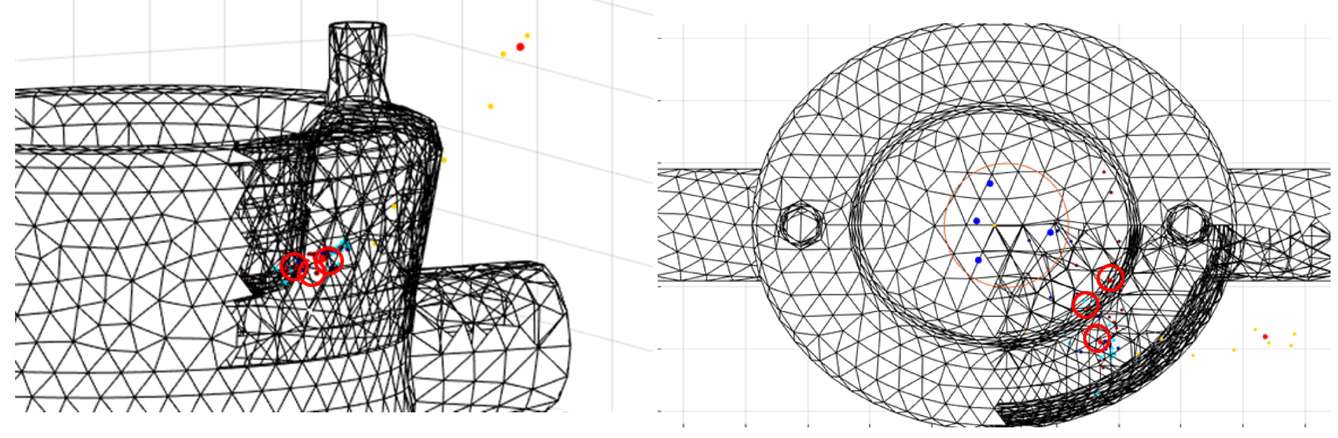
Cavity tested in vertical test stand at 2K, in stiffening frame. Two TES wafers, 4 sensors cabled each, placed above and below the cavity. Sensors above react to quench.





Trilateration by correlation between 3 sets of 4 sensors. Second sound source located few cm inside the cavity, at capacitive plate: deflection of wave by stiffening frame? High electric field region: impact of field emitted electrons

Calibration of cavity wrt TES possible with precisely located network of point heaters.



Cavity quenches at 38 W, with pulsating behaviour.
Transmitted power increases while cavity loads, then cavity uploads, while reflected power increases; then slowly decays as cavity loads up again.