中国科学院超导电子学卓越创新中心
CAS Center for Excellence in Superconducting Electronics (CENSE)

Soft X-ray TES detector with an overhanging absorber

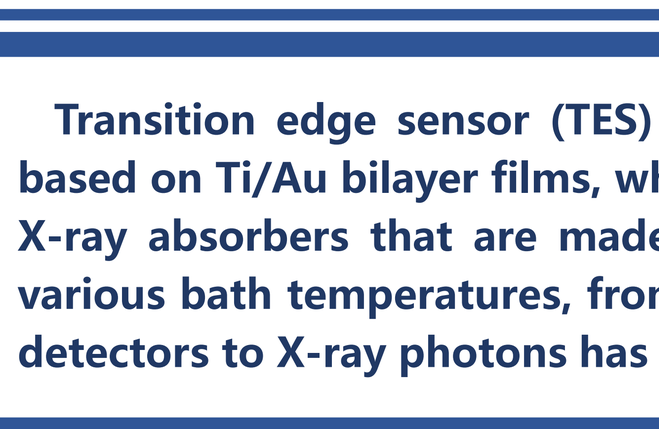
Yue Lv[1,2], Hubing Wang[1,2], Wentao Wu[1,2], Jianguo Chen[1,2], Bo GAO[1,2], Zhen Wang[1,2]

[1]CAS Center for Excellence in Superconducting Electronics (CENSE), Shanghai 200050, China
[2]Shanghai Institute of Microsystem and Information Technology, Chinese Academy of Sciences, 865 Changning Road, Shanghai 200050, China

Transition edge sensor (TES) is a sensitive low-temperature photon detector. We have fabricated TES detectors based on Ti/Au bilayer films, which are grown by using e-beam evaporation. The detectors have overhang-structured X-ray absorbers that are made by gold electroplating. We have characterized the I-V curves of the detectors at various bath temperatures, from which the heat conductance G to the thermal bath is deduced. The response of the detectors to X-ray photons has been tested by using a Fe55 radioactive source.

Research background

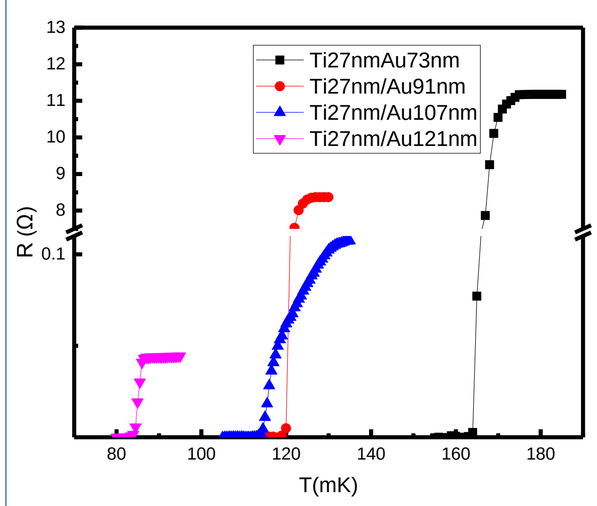
TES is a sensitive photon detector. By measuring the amplitude of signal current pulses, TES can measure precisely the energy of photons. In soft X-ray band, its energy resolution is significantly higher than semiconductor photon detectors and is comparable to that of grating detectors, and its total detection efficiency is much higher than that of grating detectors. Several major research projects in China plan to use TES to build high resolution X-ray spectrometer, such as Shanghai high repetition X-ray free electron laser (SHINE).



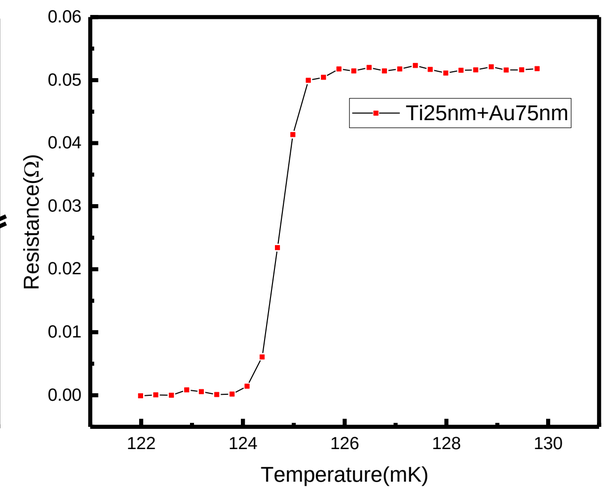
SHINE under constructions

Growth and characterization of Ti/Au bilayer films

Metal/superconductor bilayer films are often used to build TES. We have grown Ti/Au bilayer films using e-beam evaporation. The TES detector is patterned through ion beam etching.



R-T characterizations of various Ti/Au films



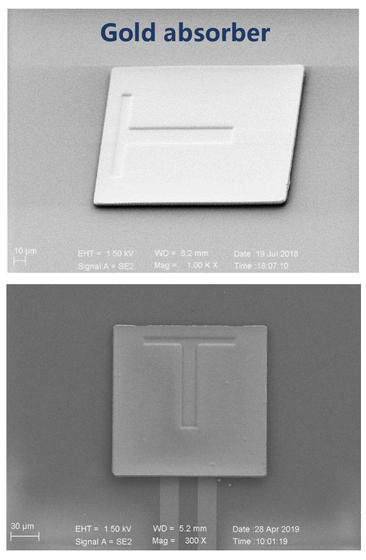
R-T characterization of a Ti/Au TES detector

Fabrication of overhang-structured absorber

We chose to fabricate overhang-structured absorber to increase the photon-sensitive area of the detector. The absorber is made by gold electro-plating method. The process flow is shown below.

Description	Material/Thickness	Schematic
0.SiN/SiOx/Si wafer 1. Nb lead 2. TES bilayer	SiN: 500 nm、SiOx: 450 nm、Si: 400 um Nb: 100nm Ti 27nm+Au 100nm	
3. Resist mold: bottom 4. Seed layer 5. Resist mold: top 6. Electroplating	Ti 10nm + Au 100nm(E-beam Evaporation) Au: 4um	
7. Remove top resist 8. IBE etch seed layer 9. Remove bottom resist	Ti 10nm + Au 100nm	
10. Back resist mold 11. Deep Si etching 12. HF etch SiOx	AZ 9260: 7um Si: 400um SiOx: 450nm	
Si SiOx SiN TiAu Nb Seed layer Au Bottom resist Top resist		

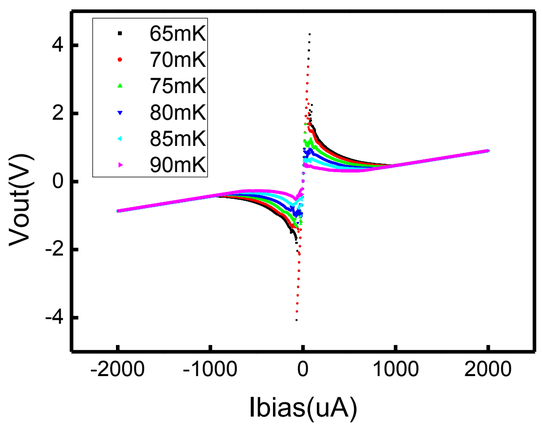
Process flow of TES detector fabrication



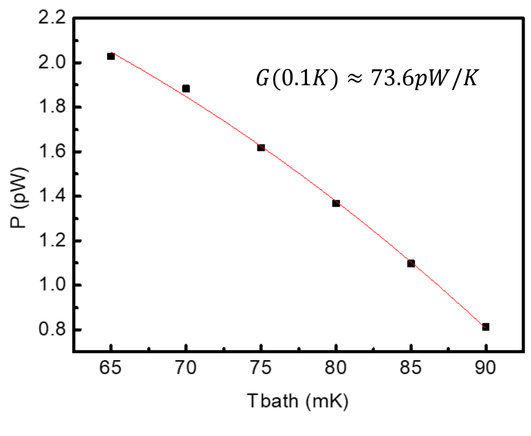
Gold absorber integrated with detector

Preliminary characterizations of Ti/Au detectors

We use two-stage SQUID amplifiers (Star Cryoelectronics) to measure the R-T and I-V curves of Ti/Au detectors, and to record the response of these detectors to incident X-ray photons. Thermal and electric parameters of the detectors are deduced from these measurements.



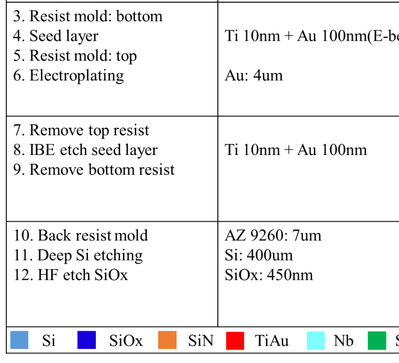
I-V curves of a Ti/Au detector measured at various bath temperature



Power vs Tbath curve of the TES

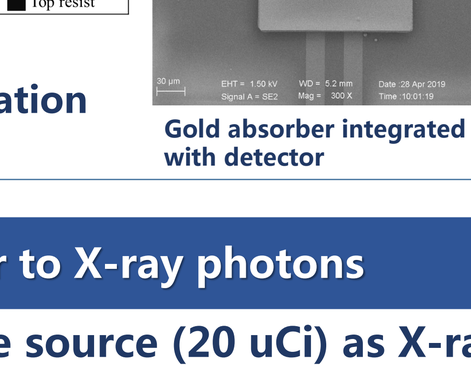
Response of the detector to X-ray photons

We use a weak Fe55 radioactive source (20 uCi) as X-ray photon source. The source is installed on the outer shell of our ADR. The X-ray photons go through a Be window and several infra-red filters before reach the detector.



Schematic view of our Fe55 source

The Fe55 source installed on the outer shell of our cryocooler



Conclusion and Acknowledgements

We have grown Ti/Au bilayer films using e-beam evaporation. We have also developed a process flow to fabricate Ti/Au TES detector with a overhang-structured gold absorber using gold electroplating method. The thermal and electric parameters of the detectors are deduced from R-T, I-V and other measurements. The response of the detectors to 5.9 keV X-ray photons are recorded using a two-stage SQUID amplifier. The X-ray photons are provided by a Fe55 radioactive source. The device fabrication is supported by superconducting device fabrication facility of Chinese academy of sciences. We also acknowledge the support from national science foundation of China, ministry of science and technology of China and government of Shanghai municipality.

*Contact Email：Bo GAO，bo_f_gao@mail.sim.ac.cn