FCC WEEK 2019

Material properties of relevance to cryogenic vacuum systems

Luisa Spallino, LNF-INFN

Brussels, 26th July 2019

INFN
Istituto Nazionale di Fisica Nucleare

Work Package 4: Cryogenic beam vacuum system

Task 4.4: Study vacuum stability at cryogenic temperature

Research funded by EuroCirCol project (Grant No. 654305) and supported by MICA project funded by INFN-SNC5

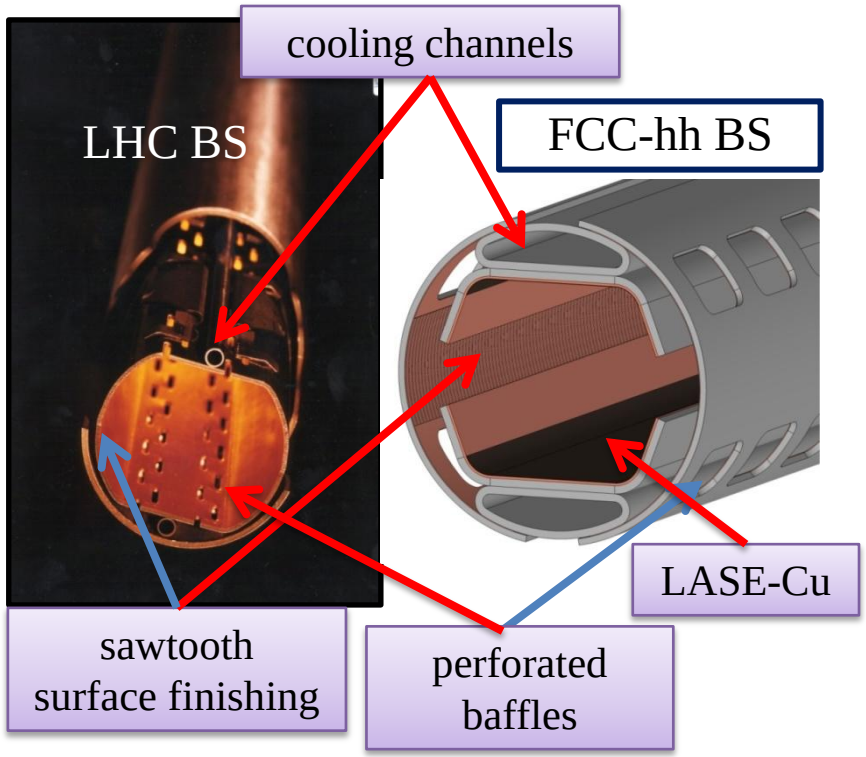
Outline

- Introduction
- Strategy and experimental set-up at LNF
- Results
  - TPD from LASE-Cu for temperature induced vacuum transients study
  - Electron desorption studies: preliminary results

Introduction

FUNCTION	PROCESS	DESIGN FEATURE
1. Increase the collider's **cooling efficiency**	Limit heat load on the 1.9 K cold mass from all sources	Beam screen held at **40 K - 60 K**
2. Avoid development of transverse resistive wall **instability**	Limit resistive wall impedance	Low-conduction support sets
3. Resist eddy-current forces during **magnet quench**	Highly resistive, structural material	P506 steel
6. Preserve magnetic **field quality**	Low permeability materials	**Double chamber** layout
5. Avoid development of **e-cloud**	Low SEY surfaces	**LASE treatment** on inner chamber
4. Keep the **gas density low**	Limit synchrotron radiation scattering	**Sawtooth treatment** on secondary chamber
	Maximize pumping speed	Pumping holes

Updated from *P. Lebrun et al. ICEC 2012*



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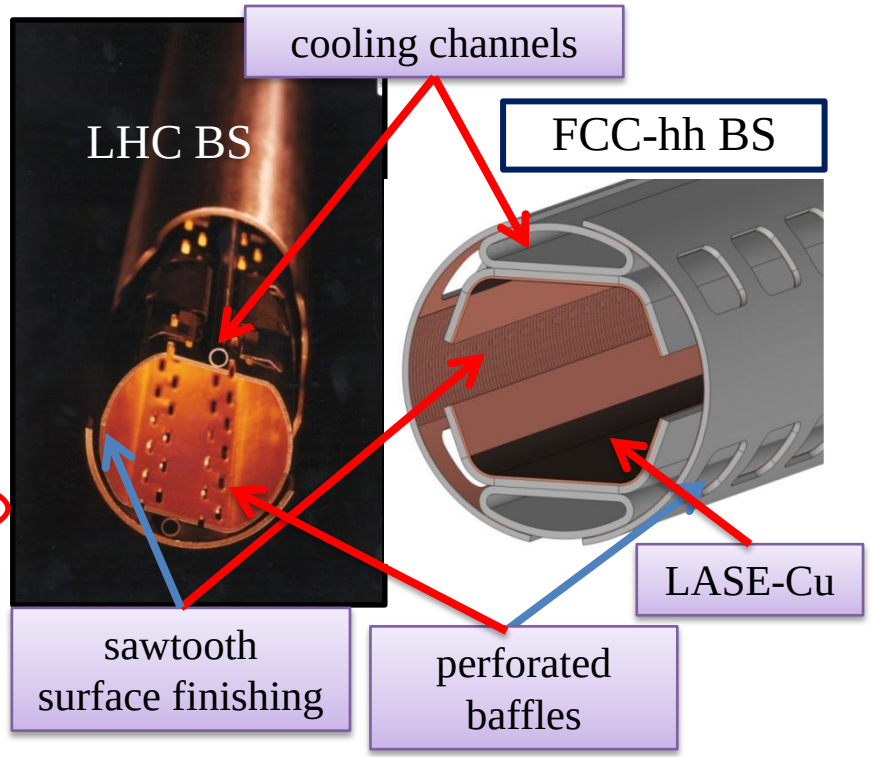
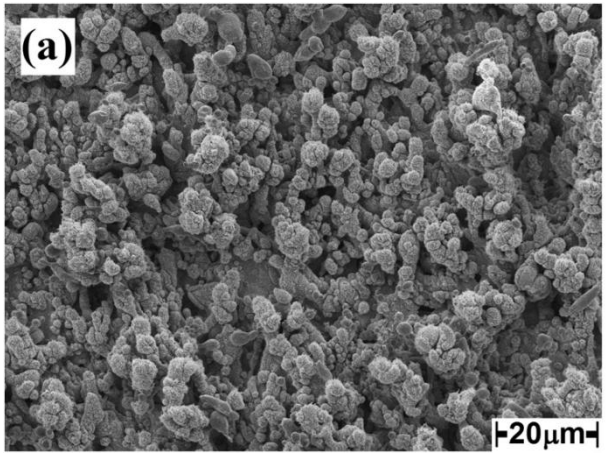


Introduction

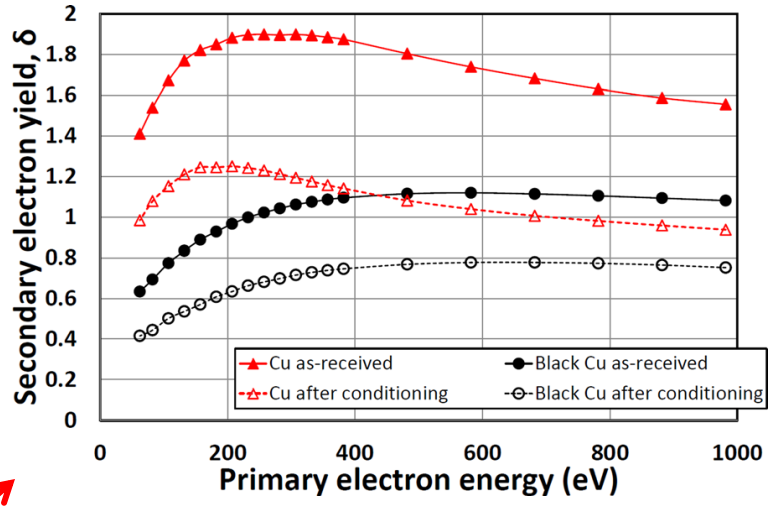
Engineering the surface morphology



R. Valizadeh et al. , Appl. Surf. Sci. (2017)

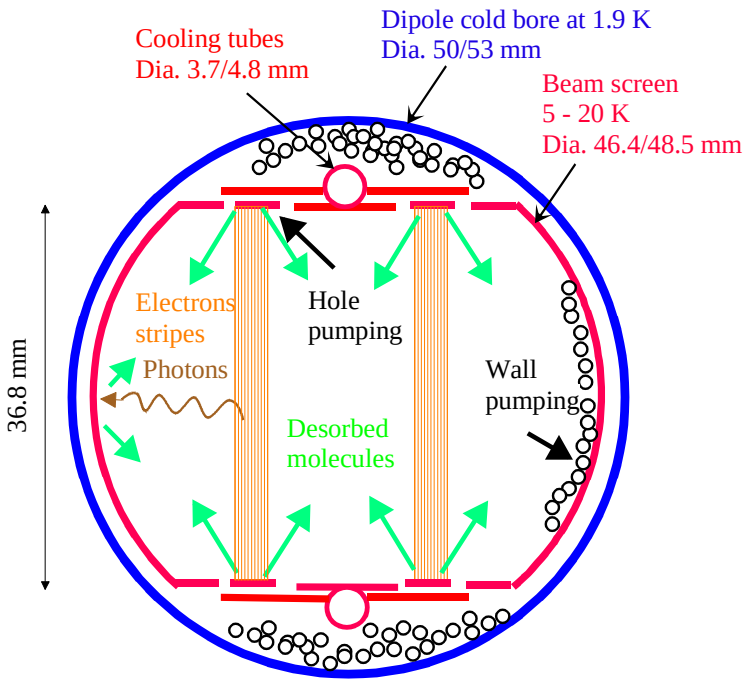
Laser ablation
and conditioning

R. Valizadeh et al. , Appl. Phys. Lett. (2014)



LASE-Cu to mitigate e-cloud effects

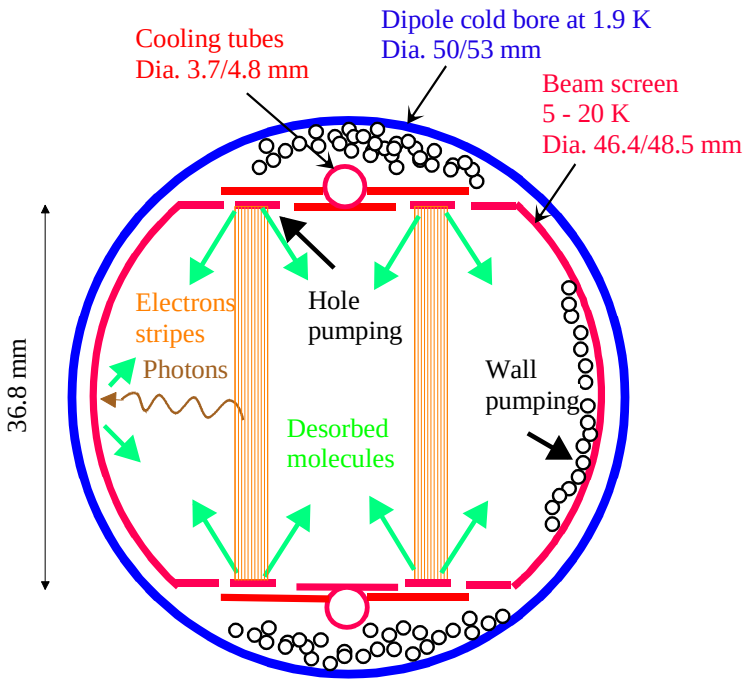
Introduction



Not only intrinsic properties of surface but also the effects of:

- **Photons-surface interaction**
- **Electrons-surface interaction**
- **Temperature transients**

Introduction



Not only intrinsic properties of surface but also the effects of:

- **Photons-surface interaction**
- **Electrons-surface interaction**
- **Temperature transients**

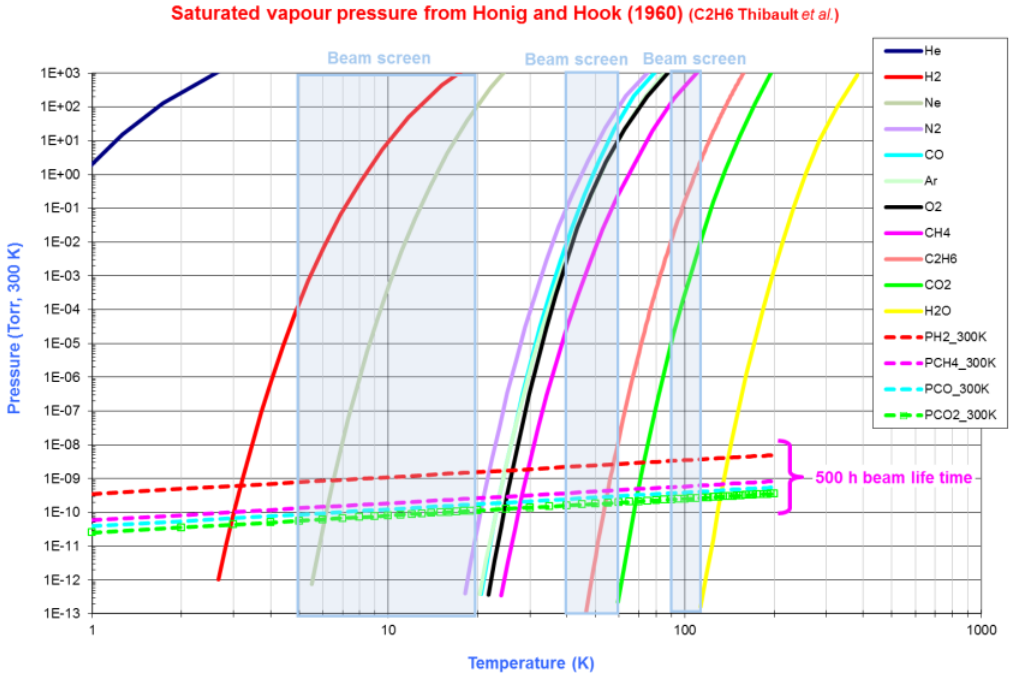
Operation Temperature

LHC
Synchrotron Radiation Power = 0.13 W/m

FCC
Synchrotron Radiation Power = 40 W/m

Working Pressure
(<10^{-11} mbar)

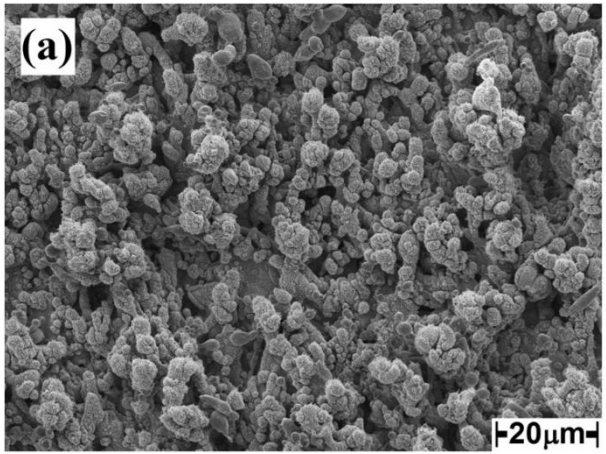
Beam screen
Temperature Range



Independently on the substrate treatment, the vacuum stability due to the desorption of residual contaminant gases has to be guaranteed

Introduction

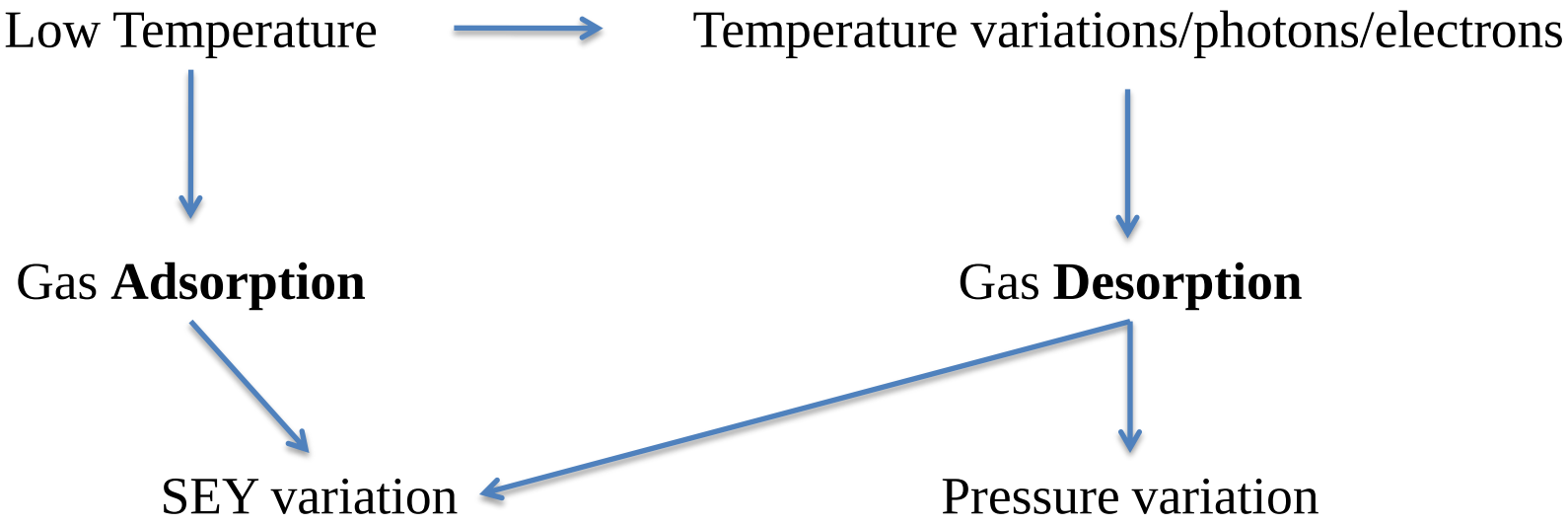
Engineering the surface morphology



R. Valizadeh et al. , Appl. Surf. Sci. (2017)

What about the influence of the surface features on vacuum stability?

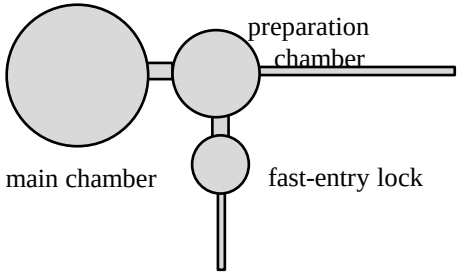
Strategy and experimental set-up at LNF



SEY, Mass Spectrometry, Thermal Programmed Desorption (TPD) and XPS (soon) as useful techniques to quantitatively follow adsorption/desorption kinetics

Strategy and experimental set-up at LNF

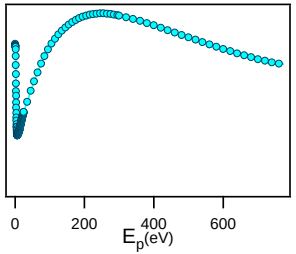
Ultra high vacuum systems

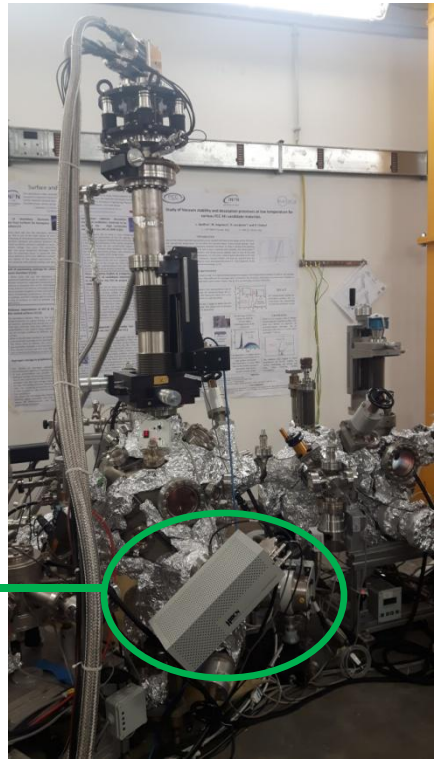


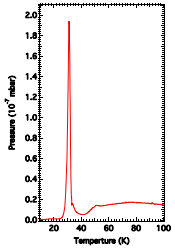
- LNF-cryogenic manipulator
- Sample at **15-300 K**

Secondary Electron Yield (SEY) measurements

Equipment : Electron gun, Faraday cup



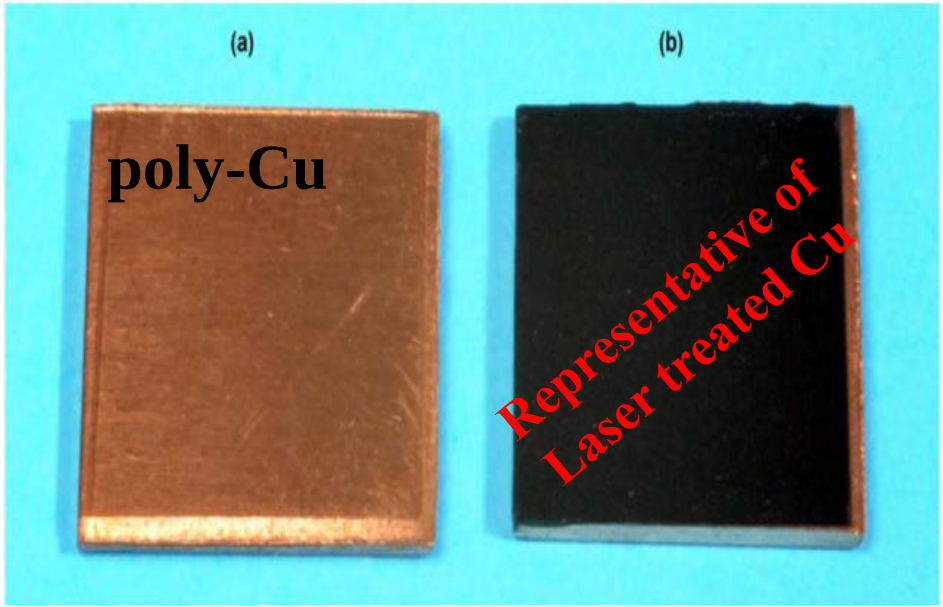




Temperature Programmed Desorption (TPD) and Mass Spectrometry measurements

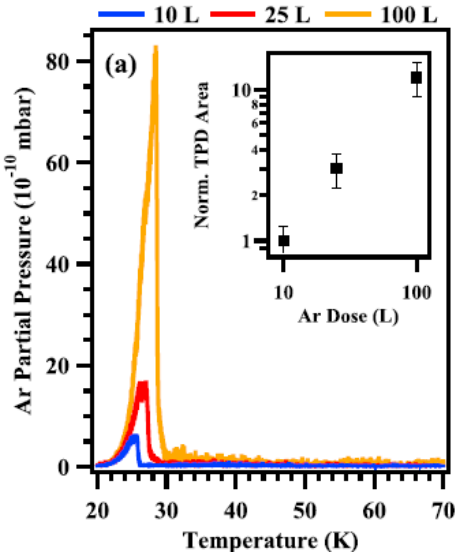
Equipment : QMS (Hiden HAL 101 Pic)

TPD from LASE-Cu for temperature induced vacuum transients study



Comparative study of TPD from flat poly-Cu and LASE-Cu samples using different gases (Ar, CH_4, CO and H_2)

TPD from LASE-Cu for temperature induced vacuum transients study: Ar



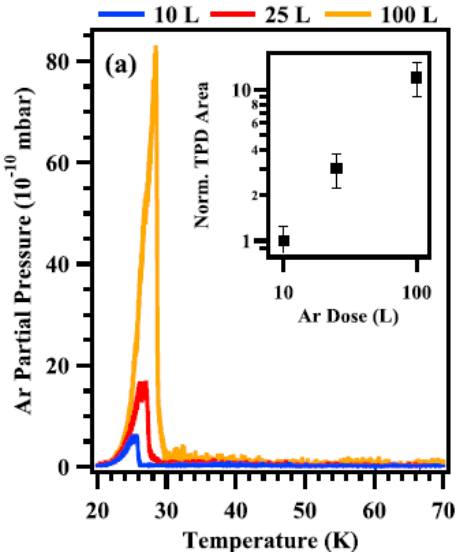
Ar on poly-Cu

Single TPD peak at ~30 K corresponding to the desorption of a condensed thick Ar layer

Desorption temperature determined by the weak Ar-Ar van der Waals interaction energies

L. Spallino, M. Angelucci, R. Larciprete, R. Cimino,
Appl. Phys. Lett. 114, 153103 (2019)

TPD from LASE-Cu for temperature induced vacuum transients study: Ar



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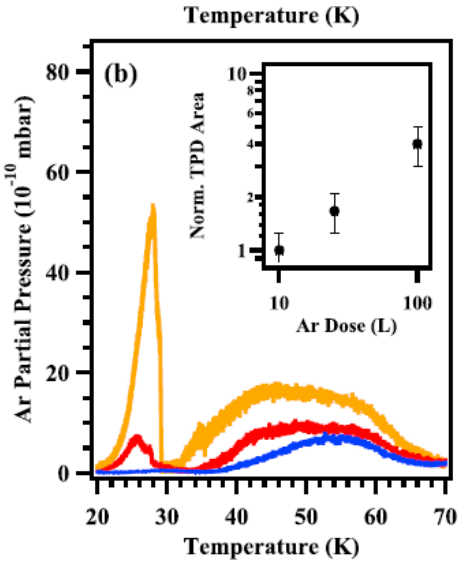
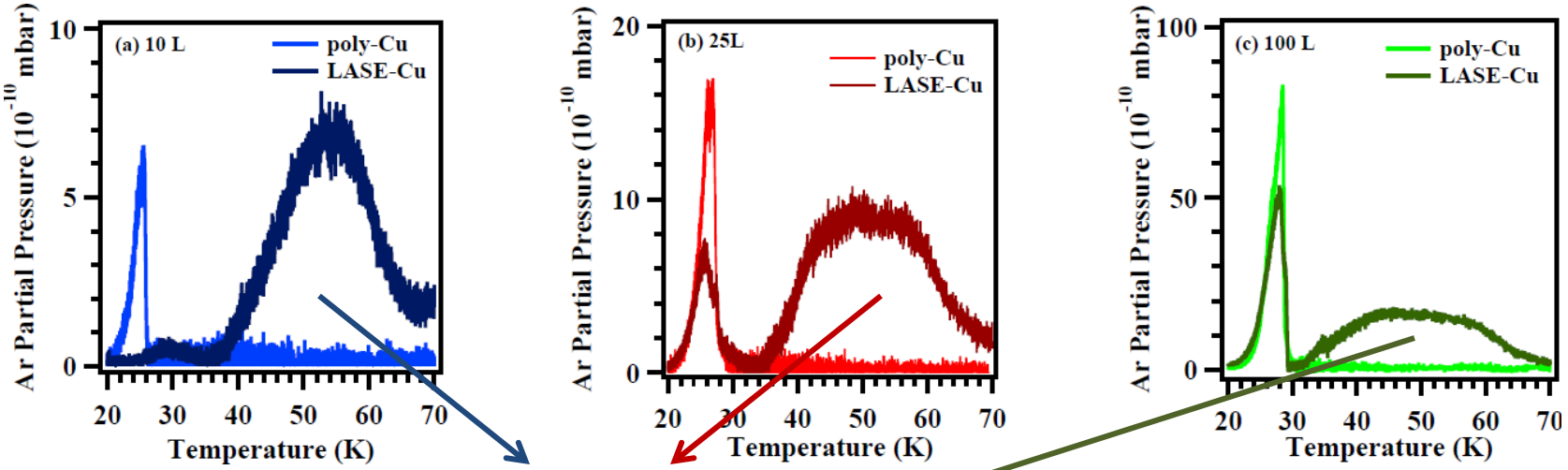
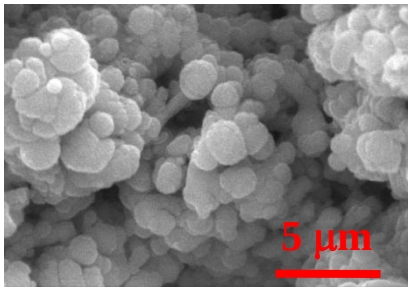
Ar on LASE-Cu

TPD peak at ~30 K corresponding to the desorption of a condensed thick Ar layer together with a broad TPD profiles, whose peak temperatures and widths depend on the Ar dose



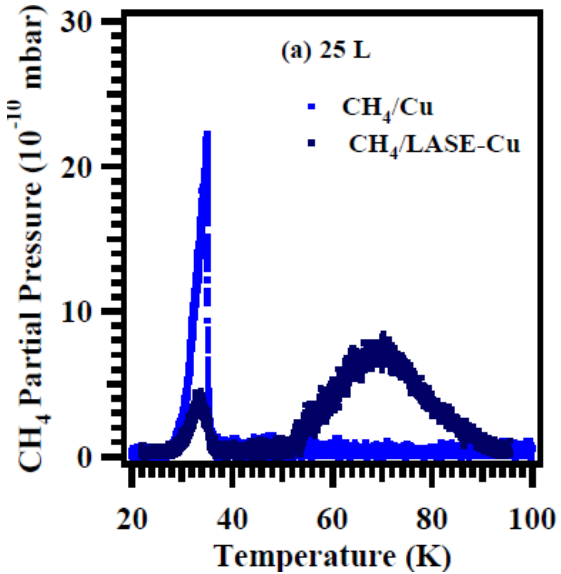
TPD from LASE-Cu for temperature induced vacuum transients study: Ar

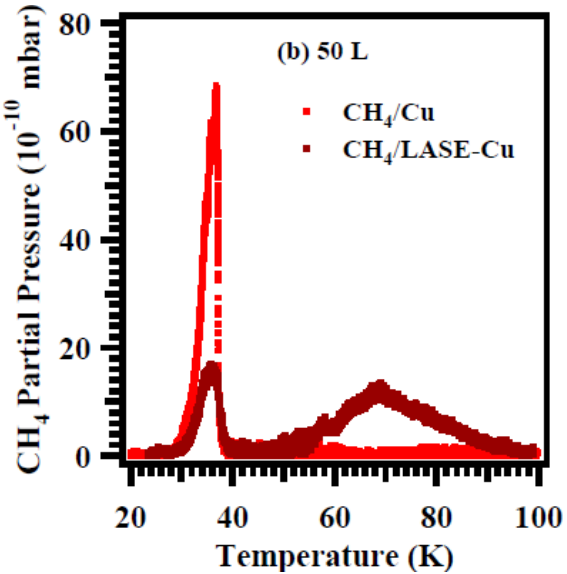


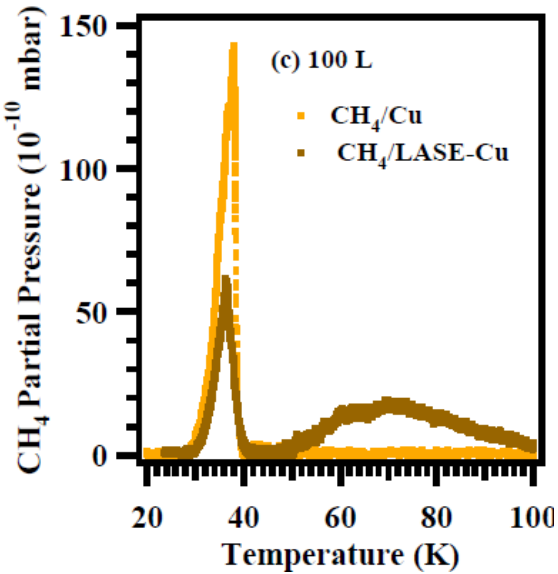


TPD characteristics determined by the sponge-like structural features of LASE-Cu

TPD from LASE-Cu for temperature induced vacuum transients study: CH_4



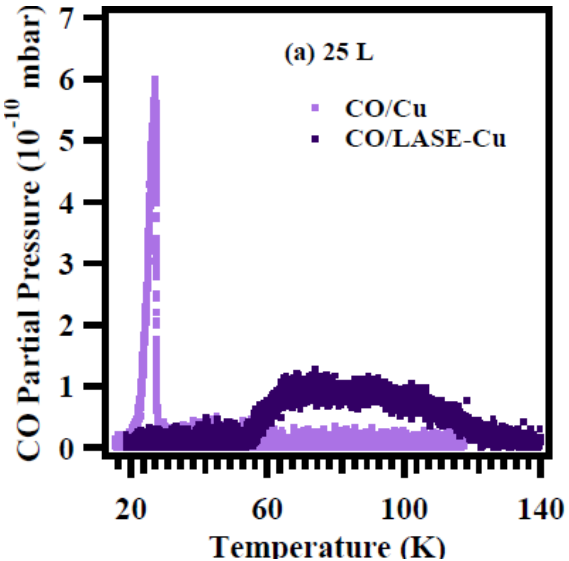


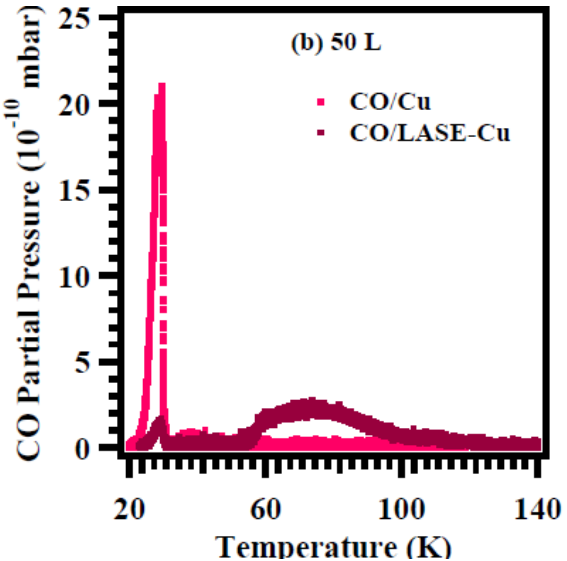


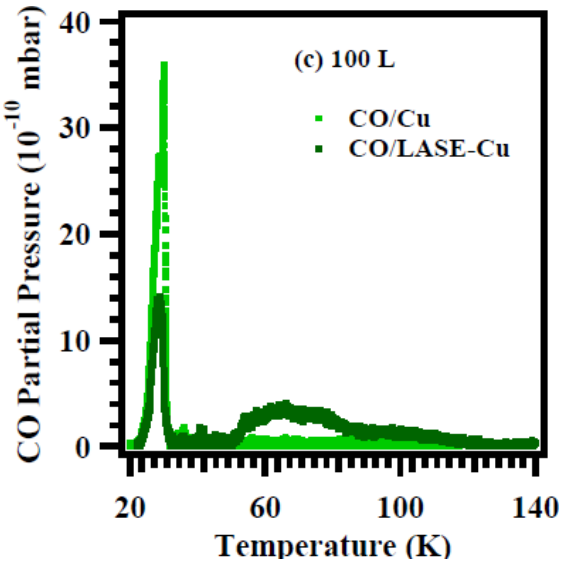
Conceptually identical to Ar results

L. Spallino, M. Angelucci and R. Cimino, to be published

TPD from LASE-Cu for temperature induced vacuum transients study: CO







Conceptually identical to Ar results

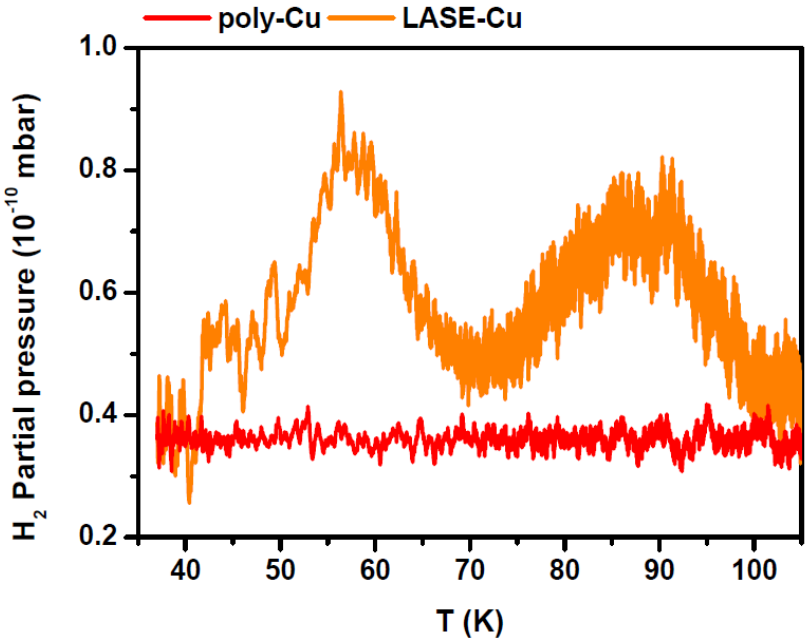
L. Spallino, M. Angelucci and R. Cimino, to be published

TPD from LASE-Cu for temperature induced vacuum transients study: H_2

TPD of 100 L H_2 dosed on poly-Cu and LASE-Cu samples held at T~15-18 K

No TPD signal should be observed by considering the H_2 vapor suture pressure curve!!!

The wide distribution of high energy adsorption sites within the inner pore is responsible for the H_2 TPD signal from LASE-Cu sample



Conceptually identical to Ar results

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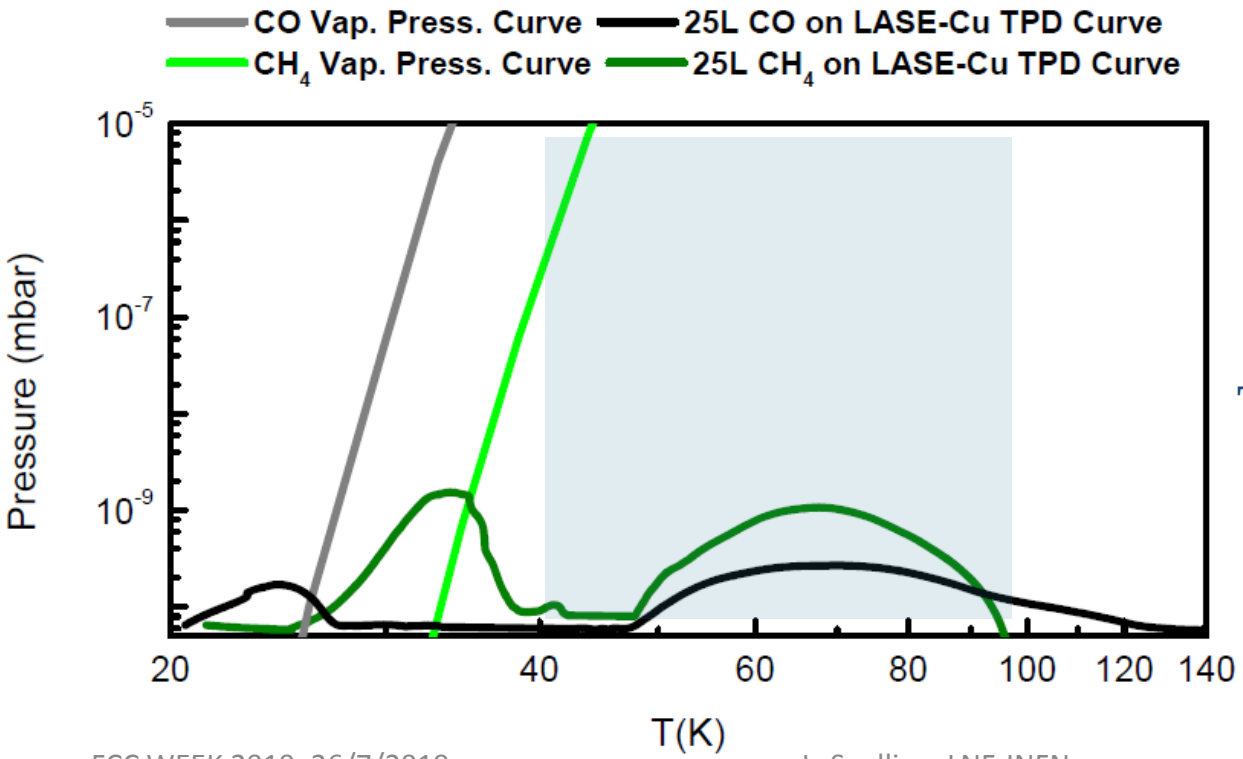
TPD from LASE-Cu for temperature induced vacuum transients study

Saturated vapour pressure from Honig and Hook (1960)

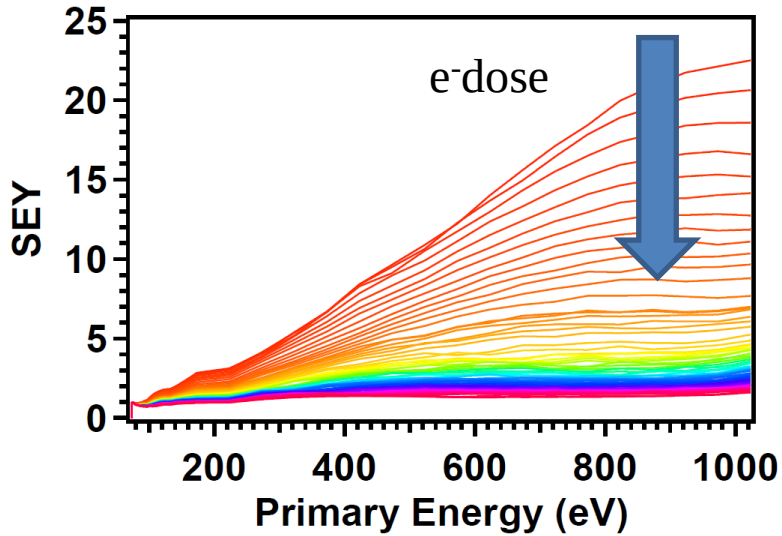


L. Spallino, M. Angelucci and R. Cimino, to be published

Further studies on this issue and on electron/photon stimulated desorption at low T are necessary to completely validate/optimize LASE-Cu.

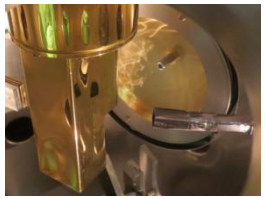
Electron desorption studies: preliminary results

Ar desorption on polycrystalline-Cu substrate as a test system



The concept of the study:

SEY measurement of a condensed gas layer induces electron desorption



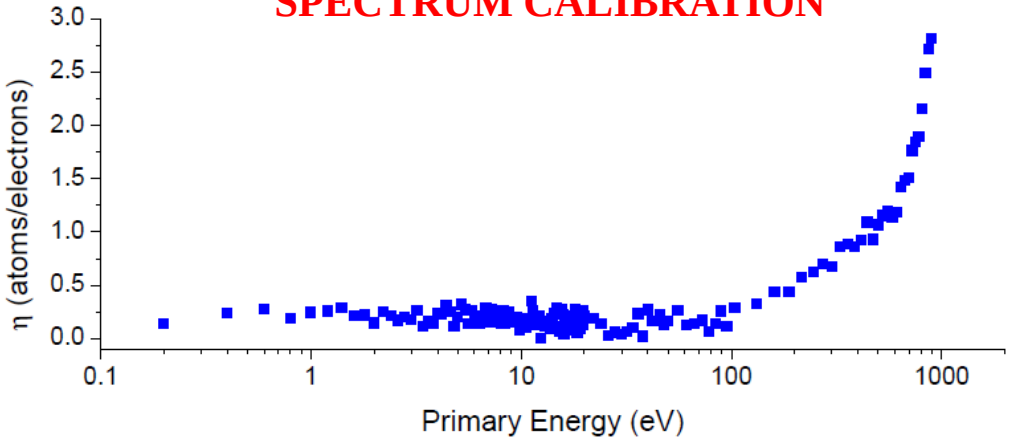
L. Spallino, M. Angelucci and R. Cimino, to be published

Electron desorption studies: preliminary results

The mass spectrum shows the sign of such electron desorption

SEY measurements, together with mass spectrometry, ideal to study ESD

FOUNDAMENTAL TO MASS SPECTRUM CALIBRATION



Thank you for your attention

Thanks to the low temperature team at LNF

Tanks to the technical support of DAΦNE-L Team: A. Grilli, M. Pietropaoli, A. Raco, V. Tullio, V. Sciarra and G. Viviani

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Divisione Ricerca: DAFNEL

EuroCirCol
A key to New Physics

Thanks to EuroCirCol project (Grant No. 654305) and V. Baglin, P. Chiggiato, R. Kersevan, O. Malyshev, and R. Valizadeh

Thanks to MICA supporting project funded by INFN-SNC5

MiCA