



Uniwersytet
Wrocławski

Właściwości ultracienkich warstw Cu na podłożu Pt(111) badane metodami AES, LEED oraz DEPES.

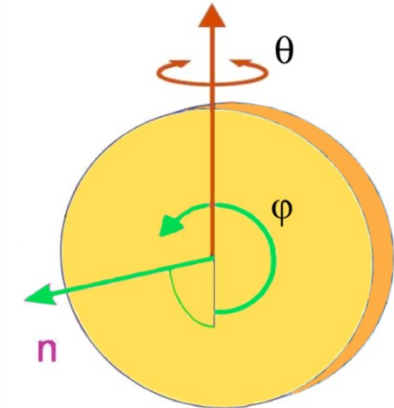
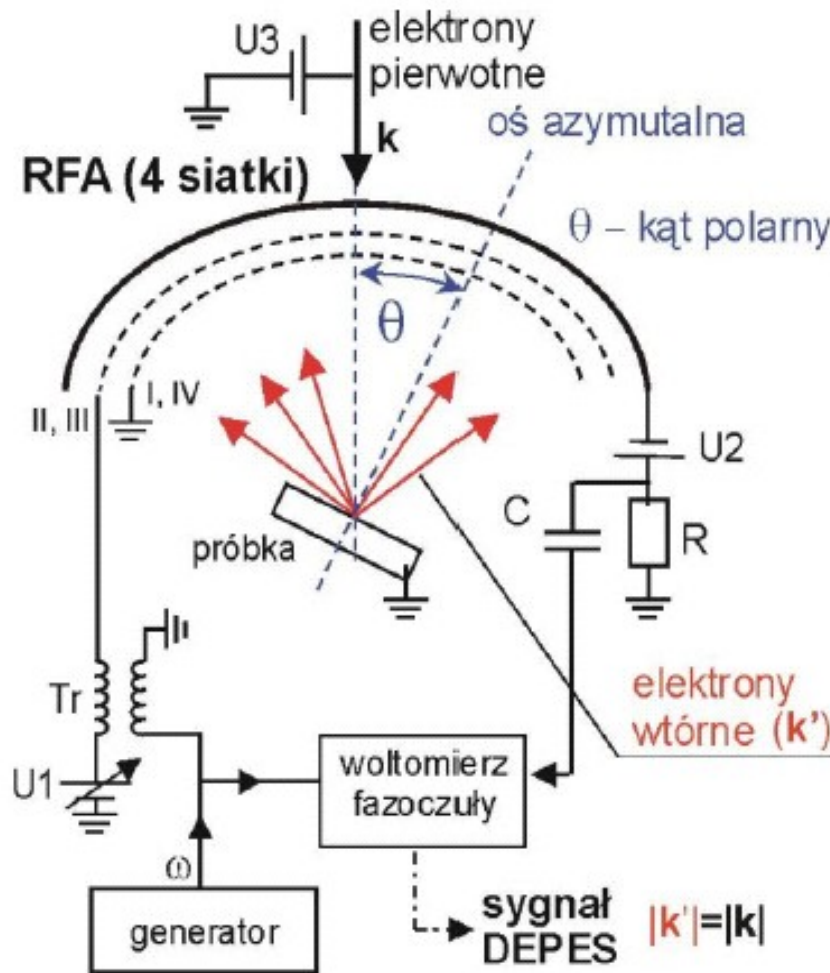
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Układ detekcji w metodzie DEPES

DEPES – Directional Elastic Peak Electron Spectroscopy
kierunkowa spektroskopia elektronowa piku elastycznego

S. Mróz, M. Nowicki, *Surf. Sci.* **297** (1993) 66



Θ - kąt polarny
 φ - kąt azymutalny

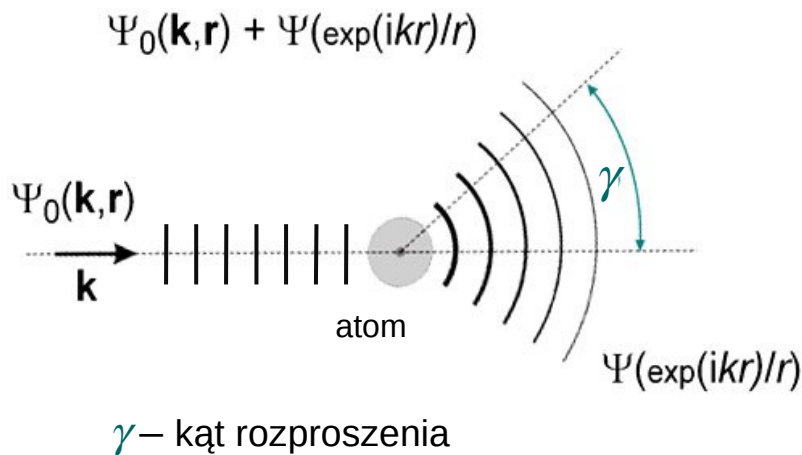
E_p w zakresie 0.5 keV - 2.0 keV.

- obrót próbki dookoła osi polarnej i rejestracja wstecznie rozproszonych elektronów (całkowanie intensywności elektronowej po dużym kącie akceptacji RFA (110°)

-zmiana kąta azymutalnego o niewielką wartość (zwykle 2°) oraz rejestracja kolejnego profilu

równanie Schrödingera:

$$-\frac{\hbar^2}{2m} \nabla^2 \Psi + V(r) \Psi = E \Psi$$

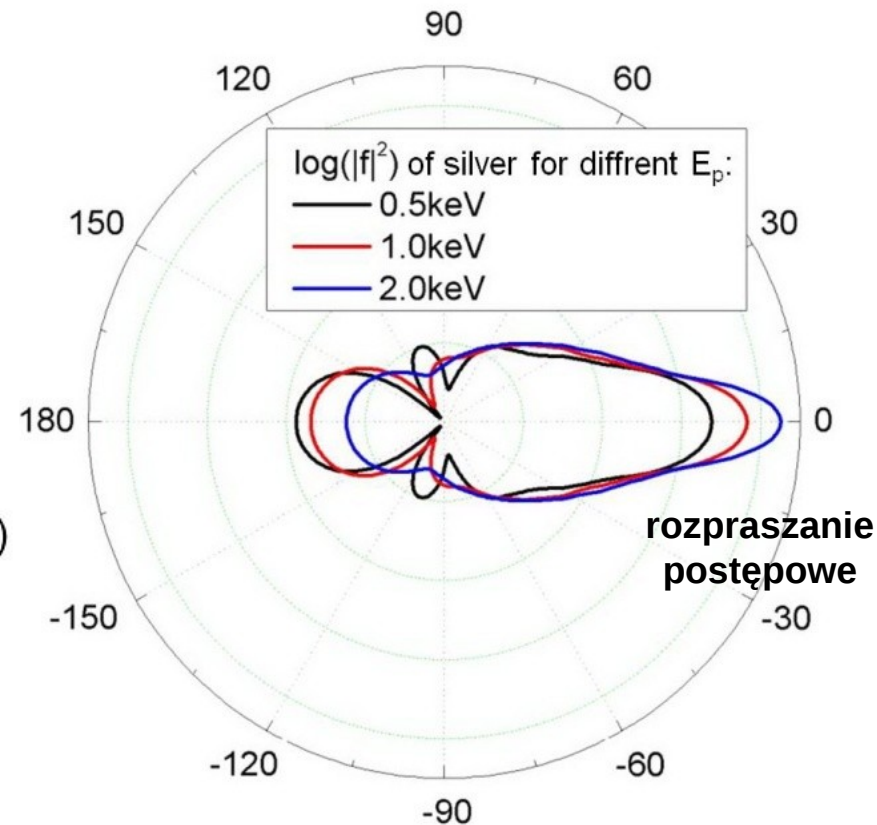


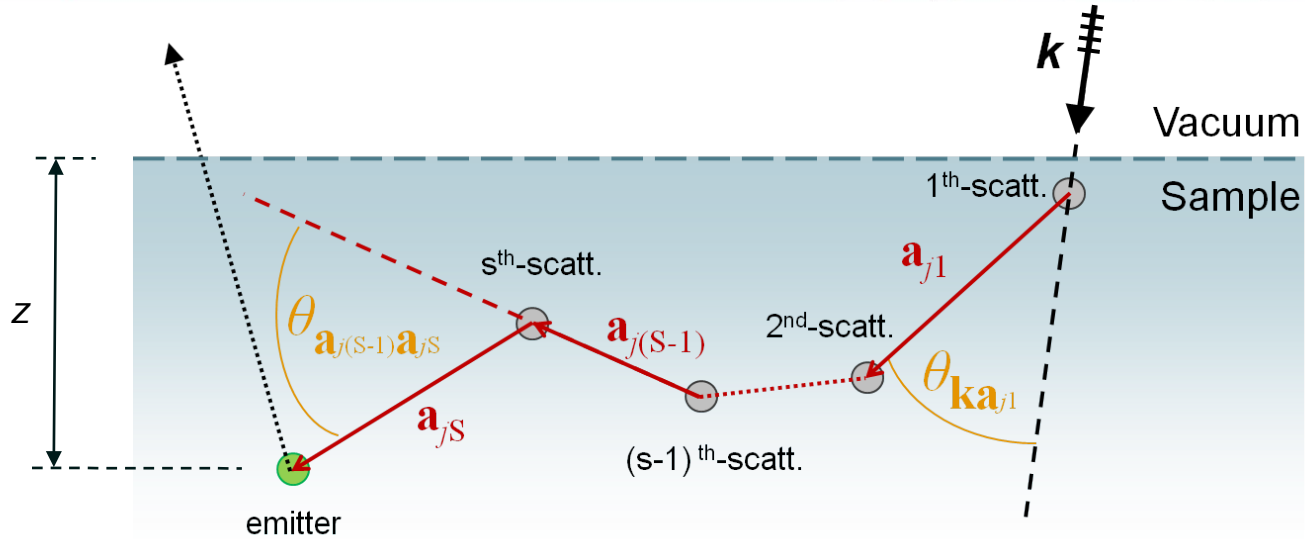
rozproszona fala:

$$\Psi_j(\mathbf{k}, \mathbf{r}) = f(r, \gamma) \frac{e^{ikr}}{r}$$

czynniki rozpraszania

wychodząca
fala
sferyczna





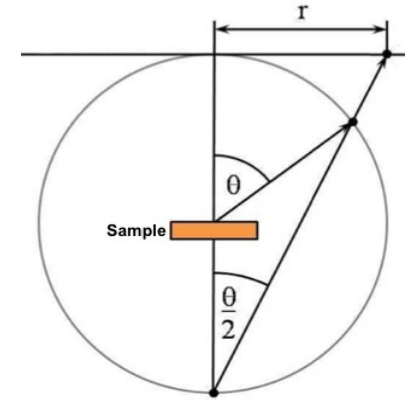
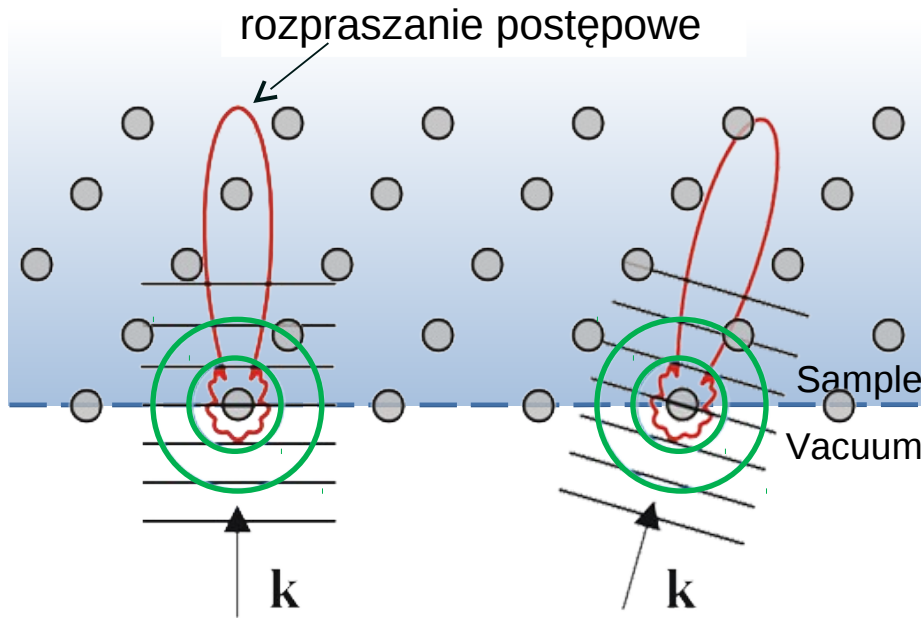
$$\Psi(\mathbf{k}, \mathbf{r}_n, s) = \psi_0(\mathbf{k}, \mathbf{r}_n) + \psi_1(\mathbf{k}, \mathbf{r}_n) + \psi_2(\mathbf{k}, \mathbf{r}_n) + \dots + \psi_s(\mathbf{k}, \mathbf{r}_n)$$

s – rząd rozproszenia

mierzona intensywność prądu na kolektorze:

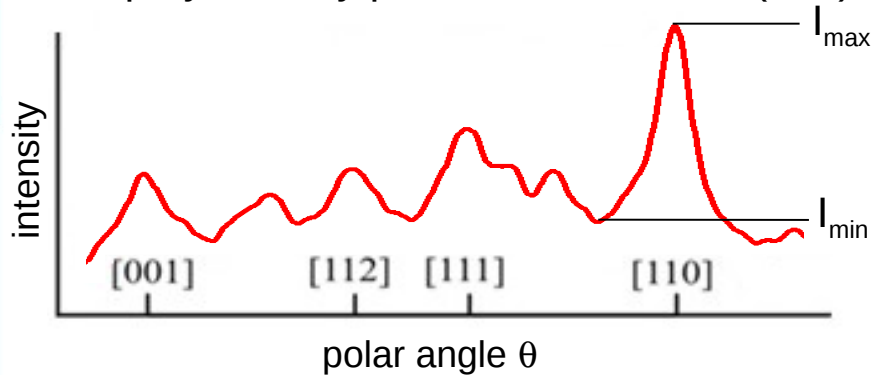
$$I(\mathbf{k}, s) \propto \sum_{\mathbf{r}_n}^N |\Psi(\mathbf{k}, \mathbf{r}_n, s)|^2 B \left(\frac{z}{\lambda_{out}}, \theta_{\mathbf{k}} \right)$$

z – odległość od powierzchni
 λ_{out} – średnia droga swobodna emitowanych elektronów
 θ – kąt nadchodzących elektronów
 B – waga emitera



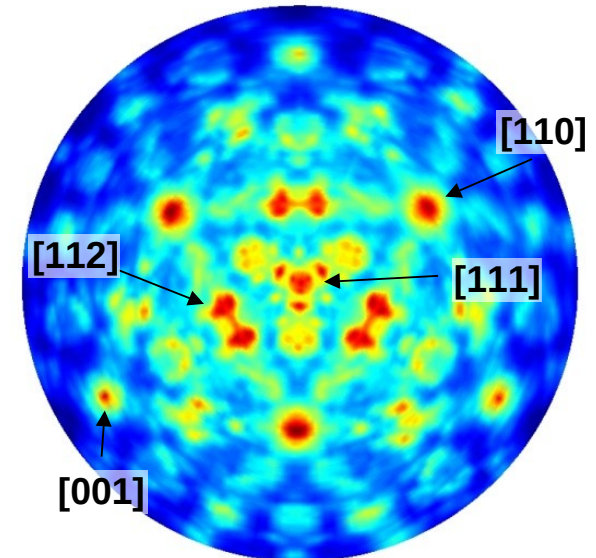
$$\begin{cases} x = r \times \sin(\varphi) \\ y = r \times \cos(\varphi) \end{cases}, \quad r = 2tg\left(\frac{\theta}{2}\right) \Rightarrow \begin{cases} x = 2tg\left(\frac{\theta}{2}\right) \sin(\varphi) \\ y = 2tg\left(\frac{\theta}{2}\right) \cos(\varphi) \end{cases}$$

przykładowy profil DEPES dla Cu(111):

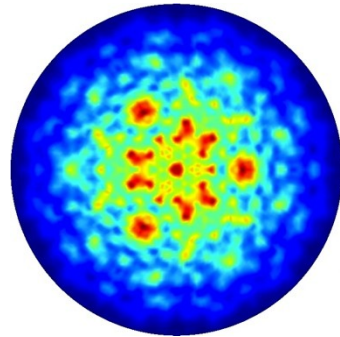


kontrast: $C(I) = 2(I_{\max} - I_{\min}) / (I_{\max} + I_{\min})$

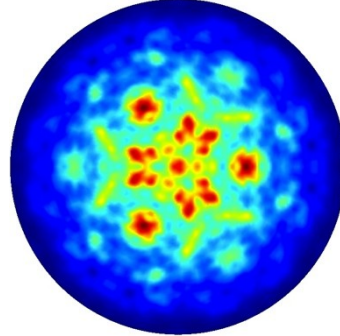
mapa DEPES Cu(111):



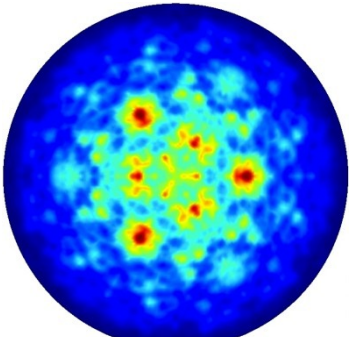
Pt(111)



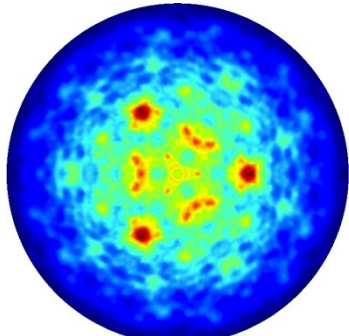
Cu/Pt(111)



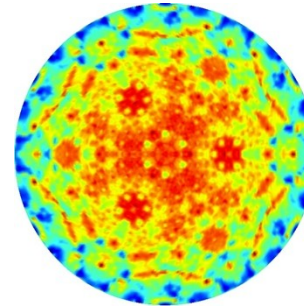
Cu(111)



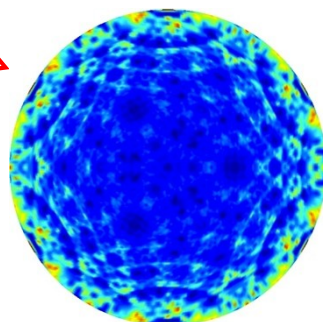
Pt/Cu(111)



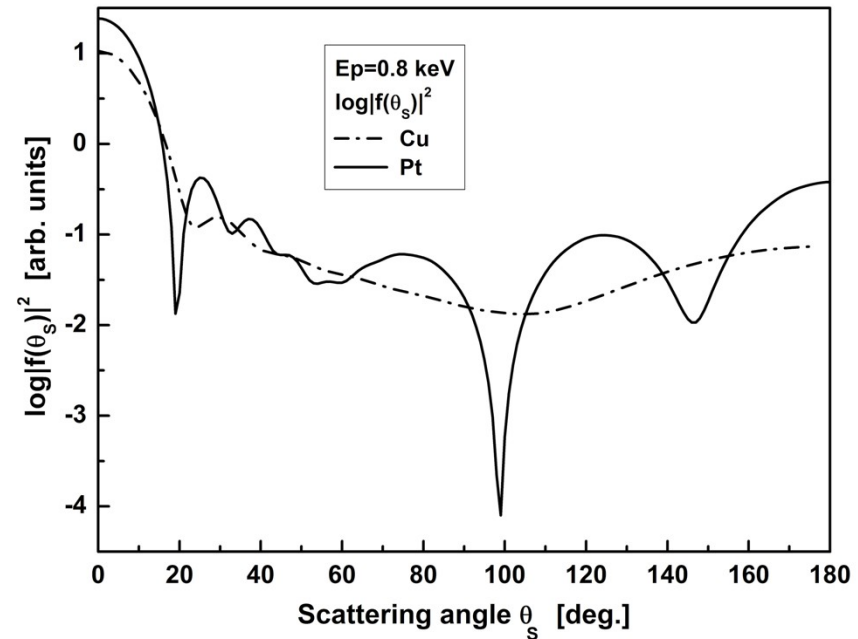
Anizotropia



Anizotropia



$$A = \frac{I(\text{Ads}) - I(\text{Sub})}{I(\text{Sub})}$$



- Cu(111)
- Pt(111)
- Pt/Cu(111)
- Cu/Pt(111)

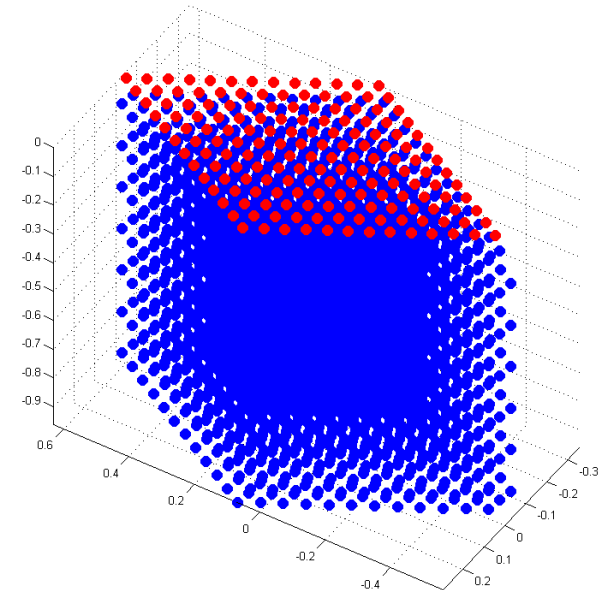
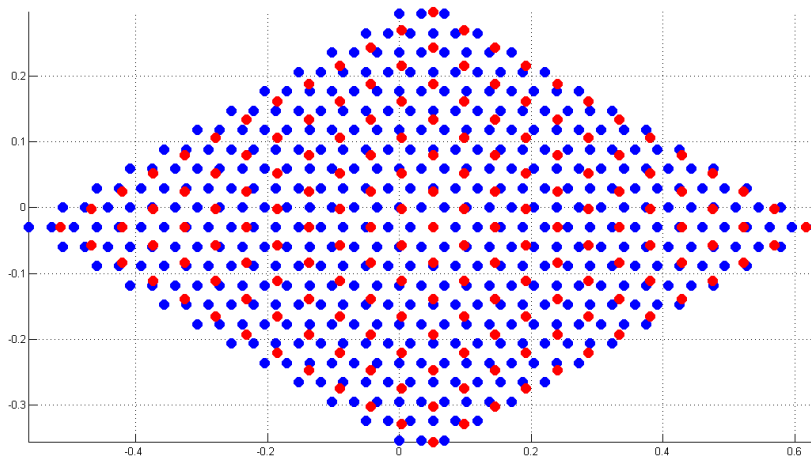
Układy Pt-Cu roszą nadzieję na wykorzystanie ich jako bardzo aktywnych katalizatorów w wielu reakcjach chemicznych oraz elektrochemicznych, np. w procesach redukcji azotu w związkach organicznych (nawozy sztuczne) lub jako katalizatory wodorowych ogniw paliwowych.

struktura
fcc(111)

różnica stałych sieci (ok. 8%) – misfit i korugacja

rekonstrukcja misfitu i korigacji

n	6	7	8	9	10	11	12	13	14	15	16	17	18
3,92 × n	23,52	27,44	31,36	35,28	39,2	43,12	47,04	50,96	54,88	58,8	62,72	66,64	70,56
3,61 × (n+1)	25,27	28,88	32,49	36,1	39,71	43,32	46,93	50,54	54,15	57,76	61,37	64,98	68,59
difference	1,75	1,44	1,13	0,82	0,51	0,2	0,11	0,42	0,73	1,04	1,35	1,66	1,97



top view

side view

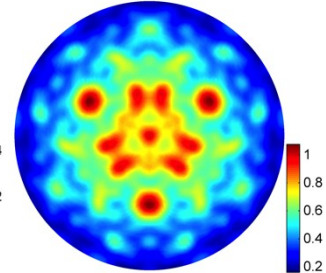
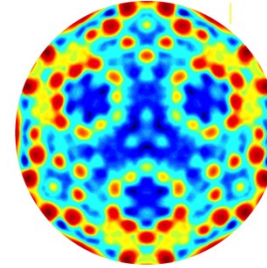
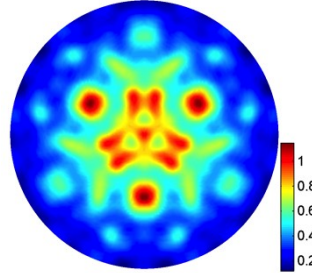
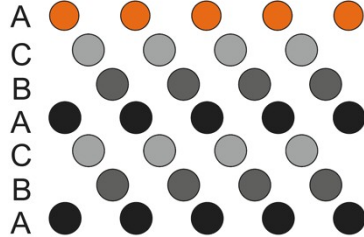
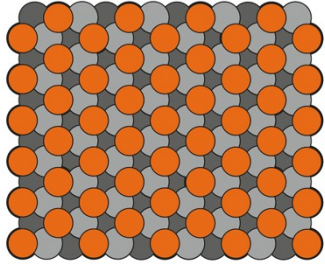
$E_p = 800 \text{ eV}$

Anisotropy

Pt(111)

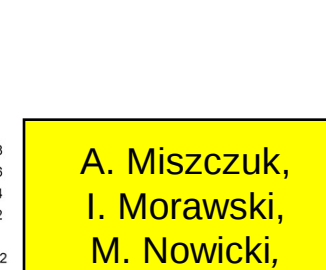
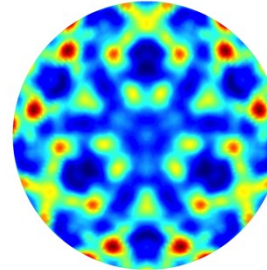
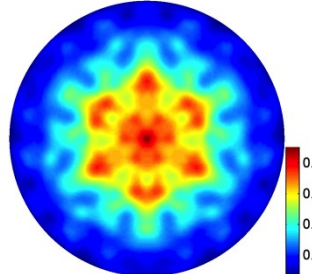
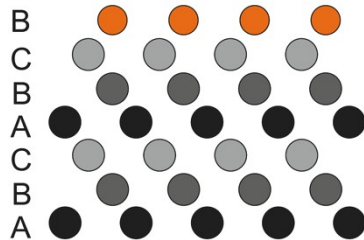
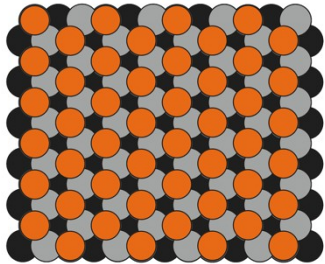
a)

A hollow site layer



b)

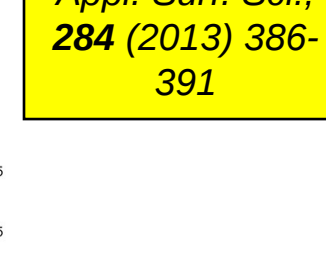
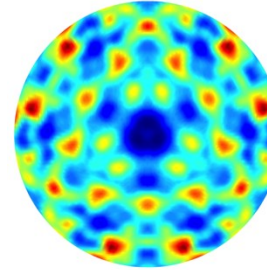
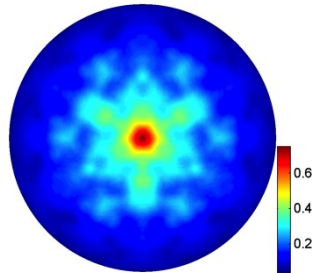
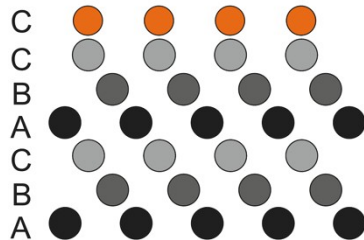
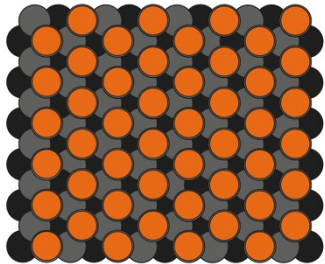
B hollow site layer



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Appl. Surf. Sci.,
284 (2013) 386-
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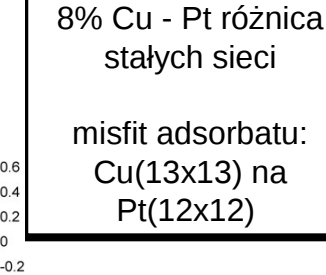
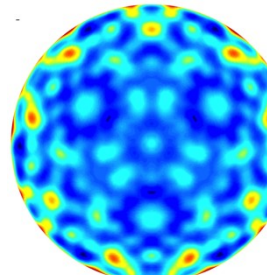
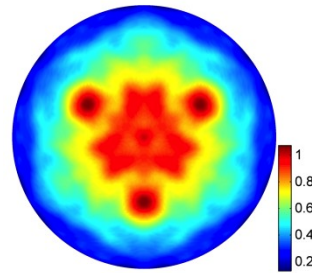
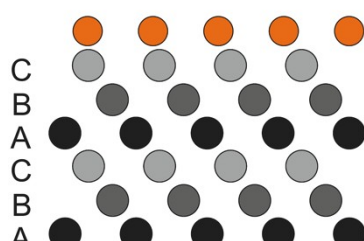
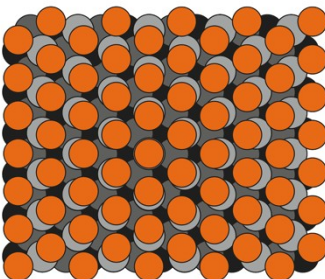
c)

on-top layer



d)

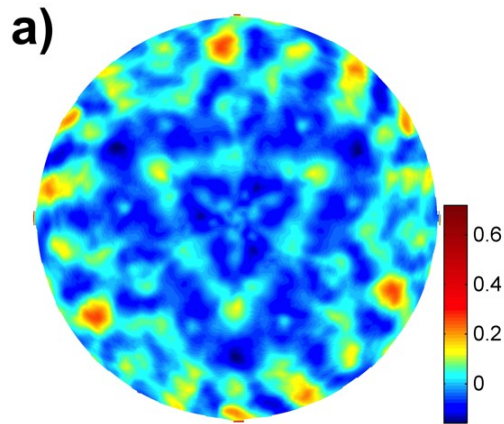
misfit layer



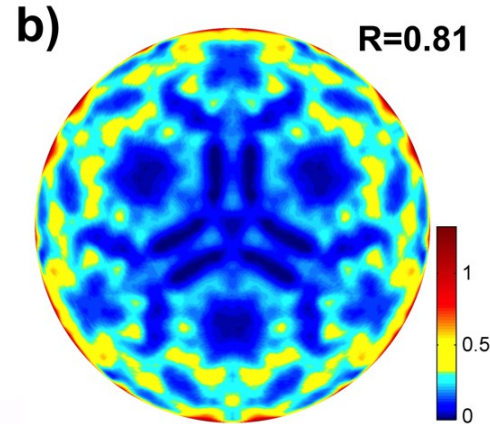
8% Cu - Pt różnica
stałych sieci

misfit adsorbatu:
Cu(13x13) na
Pt(12x12)

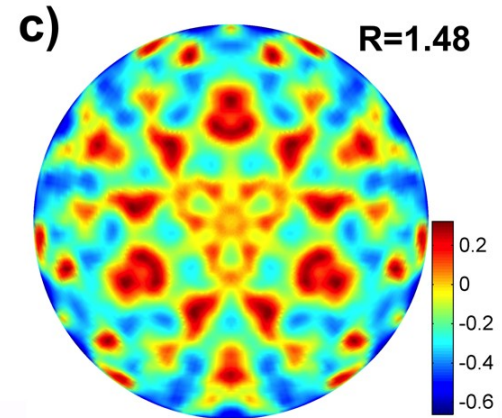
1 ML Cu/Pt(111), $E_p = 1100$ eV, $T=330$ K



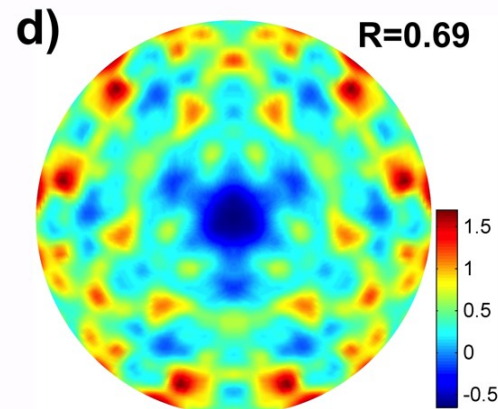
experiment



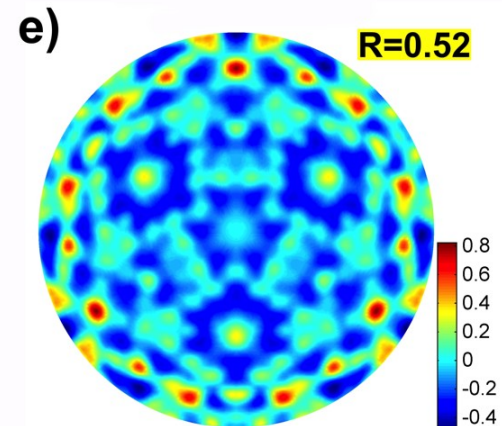
MS "A" hollow site layer



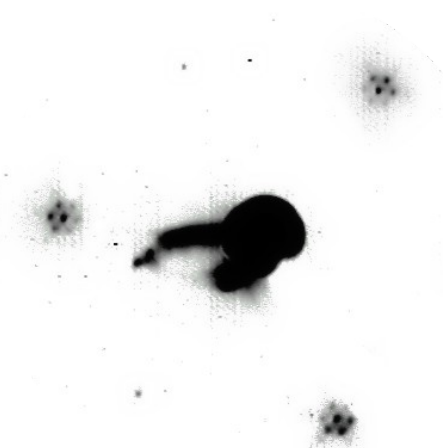
MS "B" hollow site layer



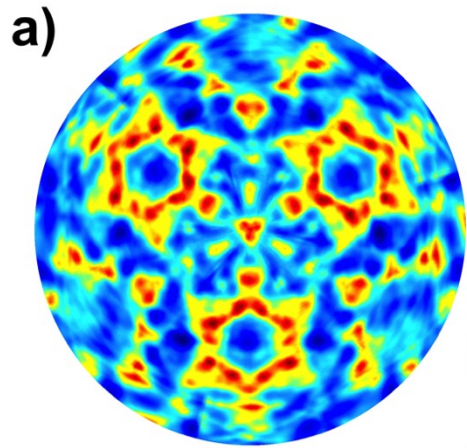
MS on-top layer



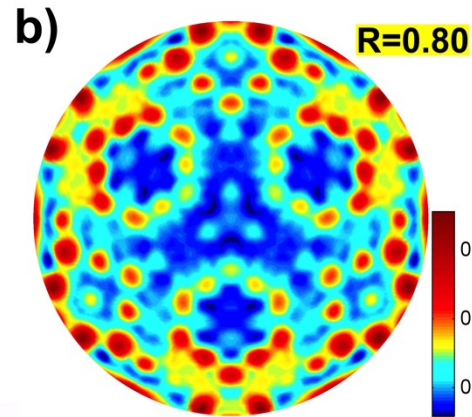
MS misfit layer



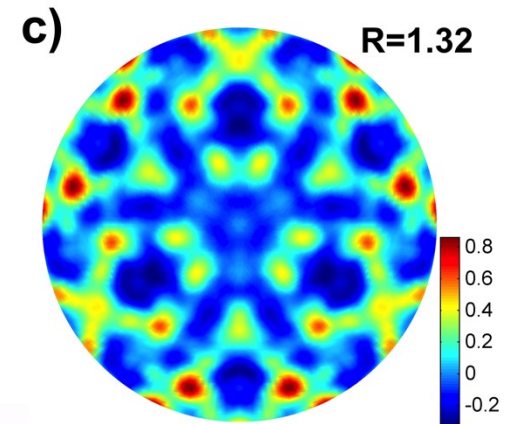
1 ML Cu/Pt(111), $E_p = 800$ eV, $T=450$ K



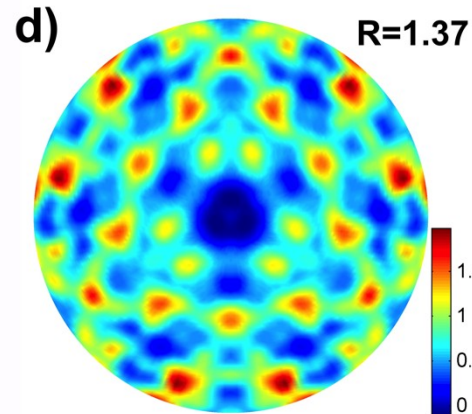
experiment



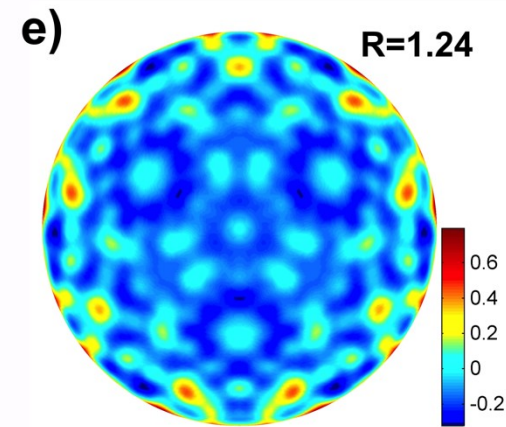
MS "A" hollow site layer



MS "B" hollow site layer



MS on-top layer



MS misfit layer



Dziękuję za uwagę