

Influence of hydrogen on the properties of nanostructured C-Pd films for sensing applications

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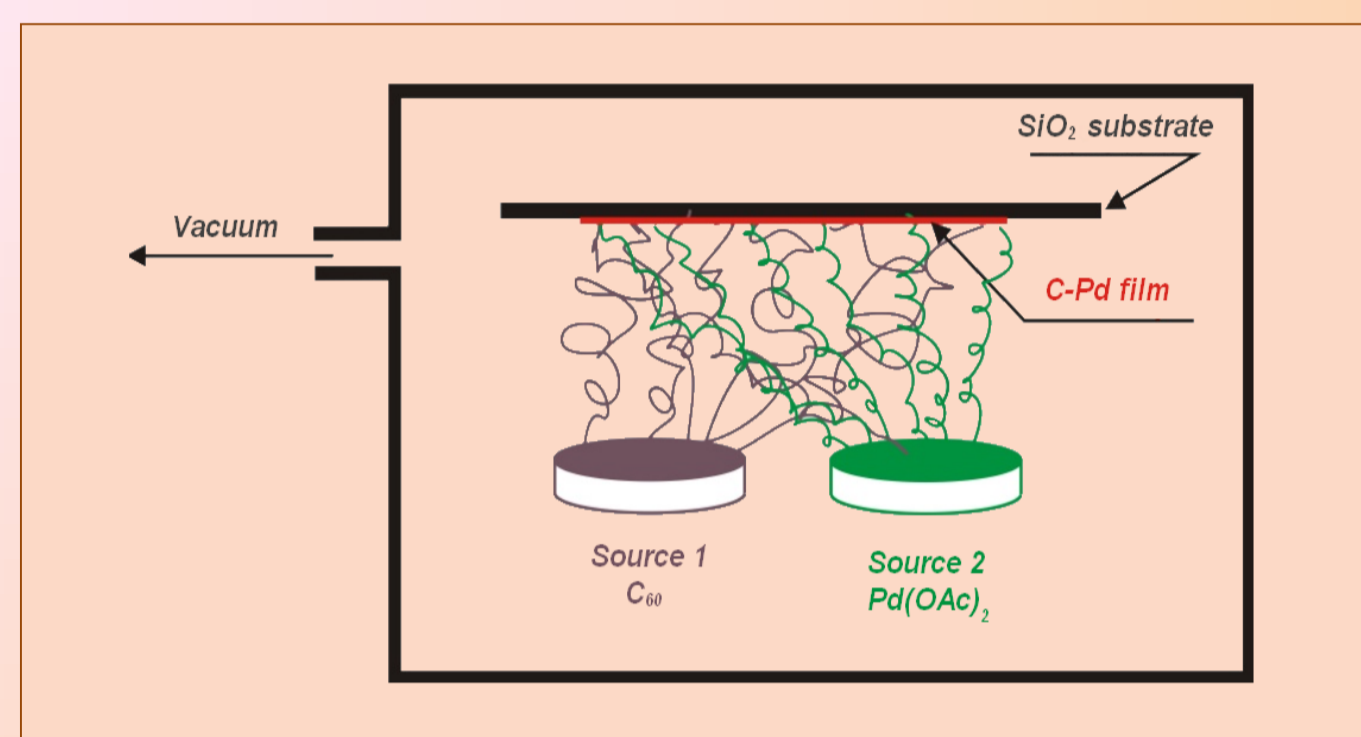
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Introduction

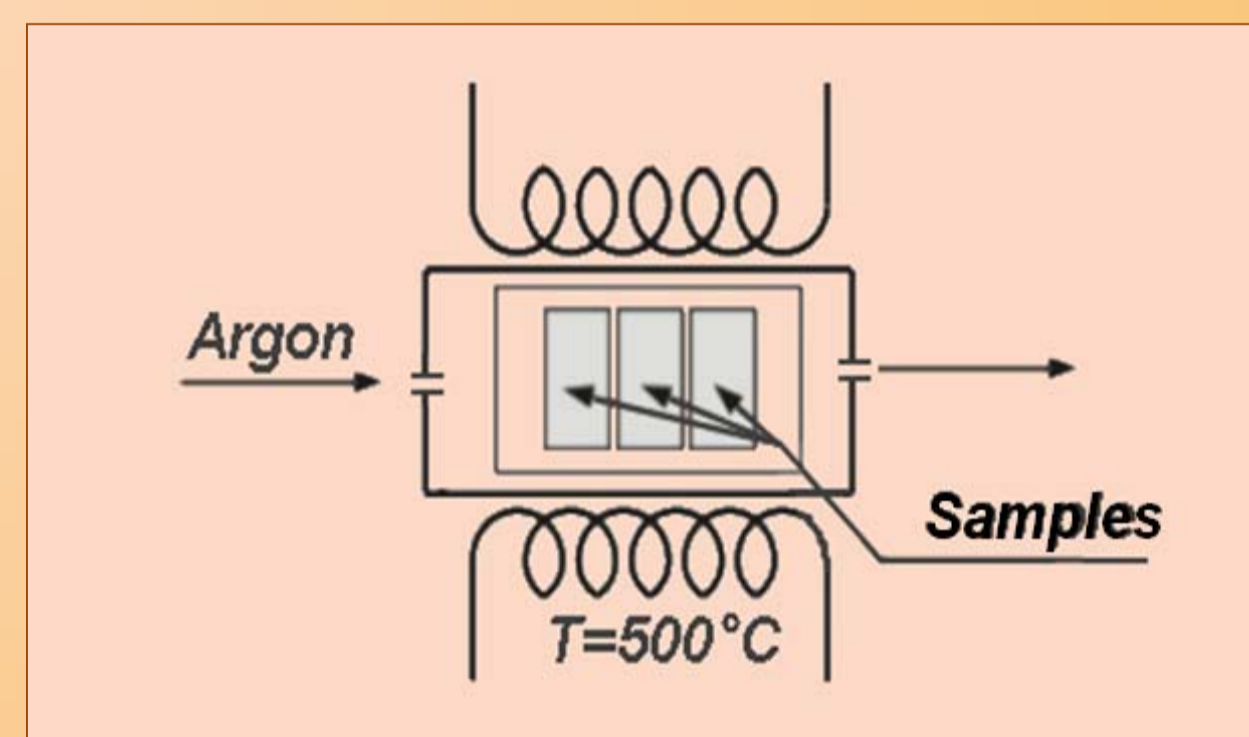
Nanostructured carbonaceous-palladium films (C-Pd films) prepared by Physical Vapor Deposition (PVD) method and annealed in argon atmosphere at the temperature of 500°C interact with hydrogen and change their resistance with changing hydrogen concentration. This behavior is connected to the adsorption and dissolution of hydrogen in palladium nanograins. In this presentation we showed that at lower hydrogen concentrations (up to 2%) the film response increased proportionally to [H₂], while above 2% H₂ it was almost constant. This is connected with formation of solid solution of hydrogen in palladium at lower H₂ concentrations and creation of palladium hydride at higher H₂ concentrations. X-ray diffraction was used to confirm the formation of Pd-H solid solution and palladium hydride.

Preparation of C-Pd films

Physical Vapor Deposition (1st step)

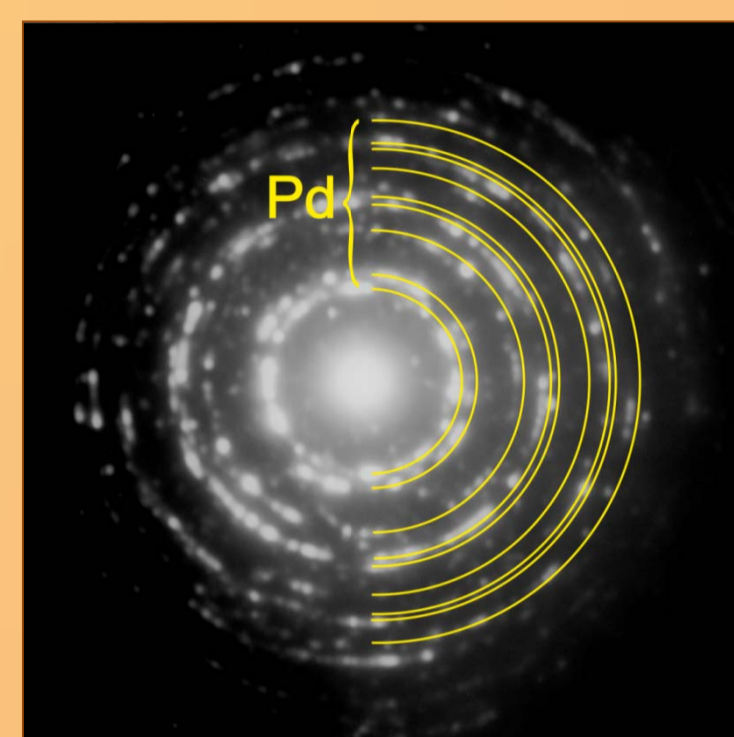


Annealing in argon atmosphere (2nd step)

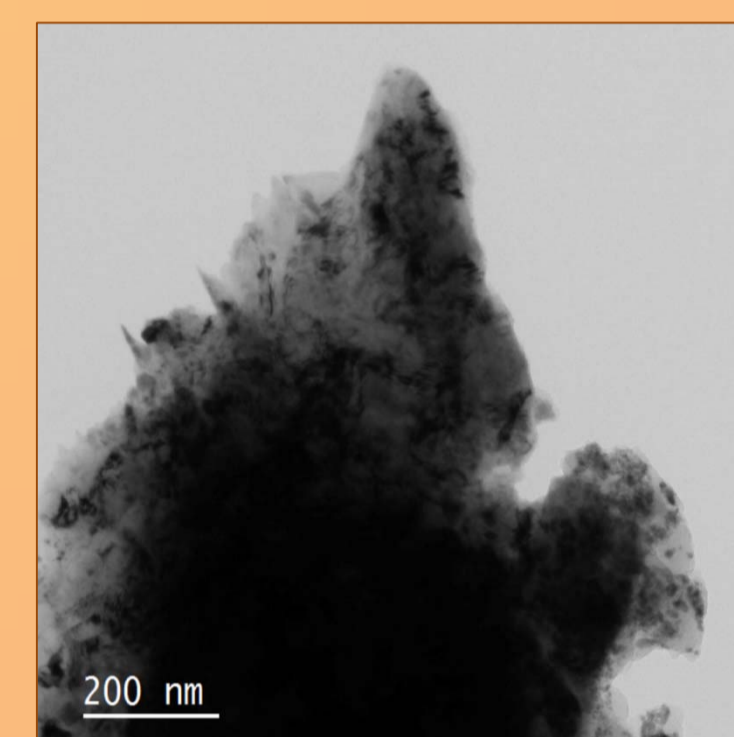


Characterization of C-Pd films

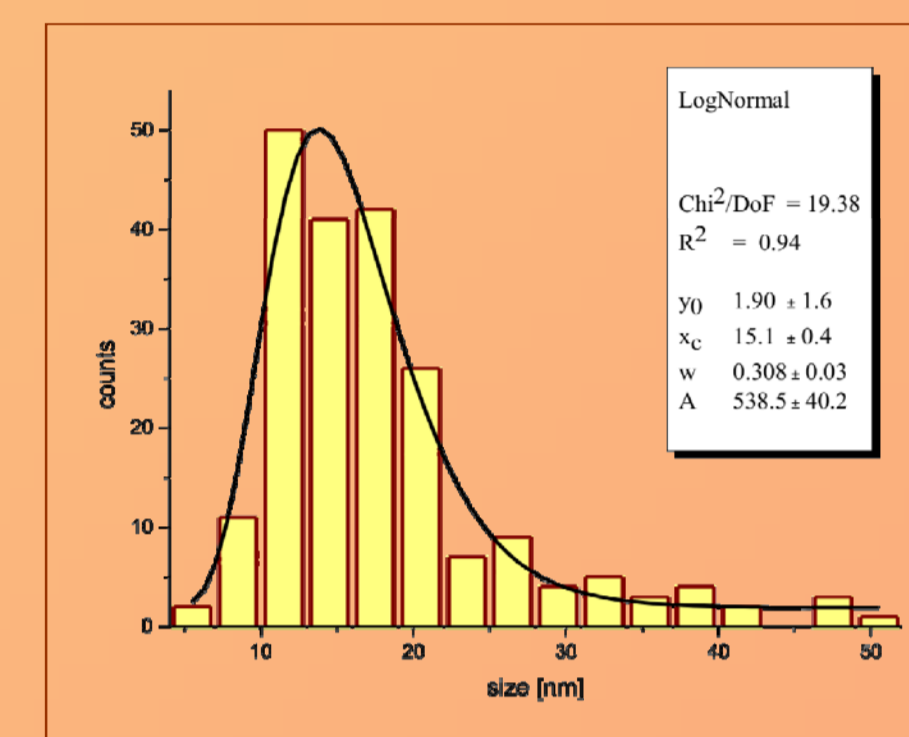
Electronogram



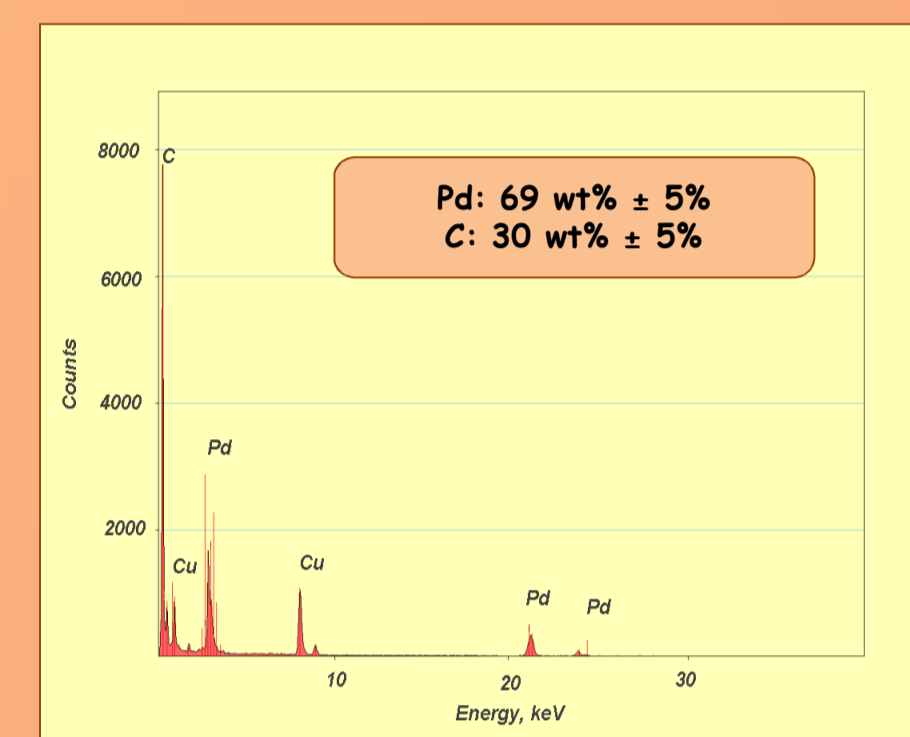
TEM micrograph



Pd nanograin size distribution

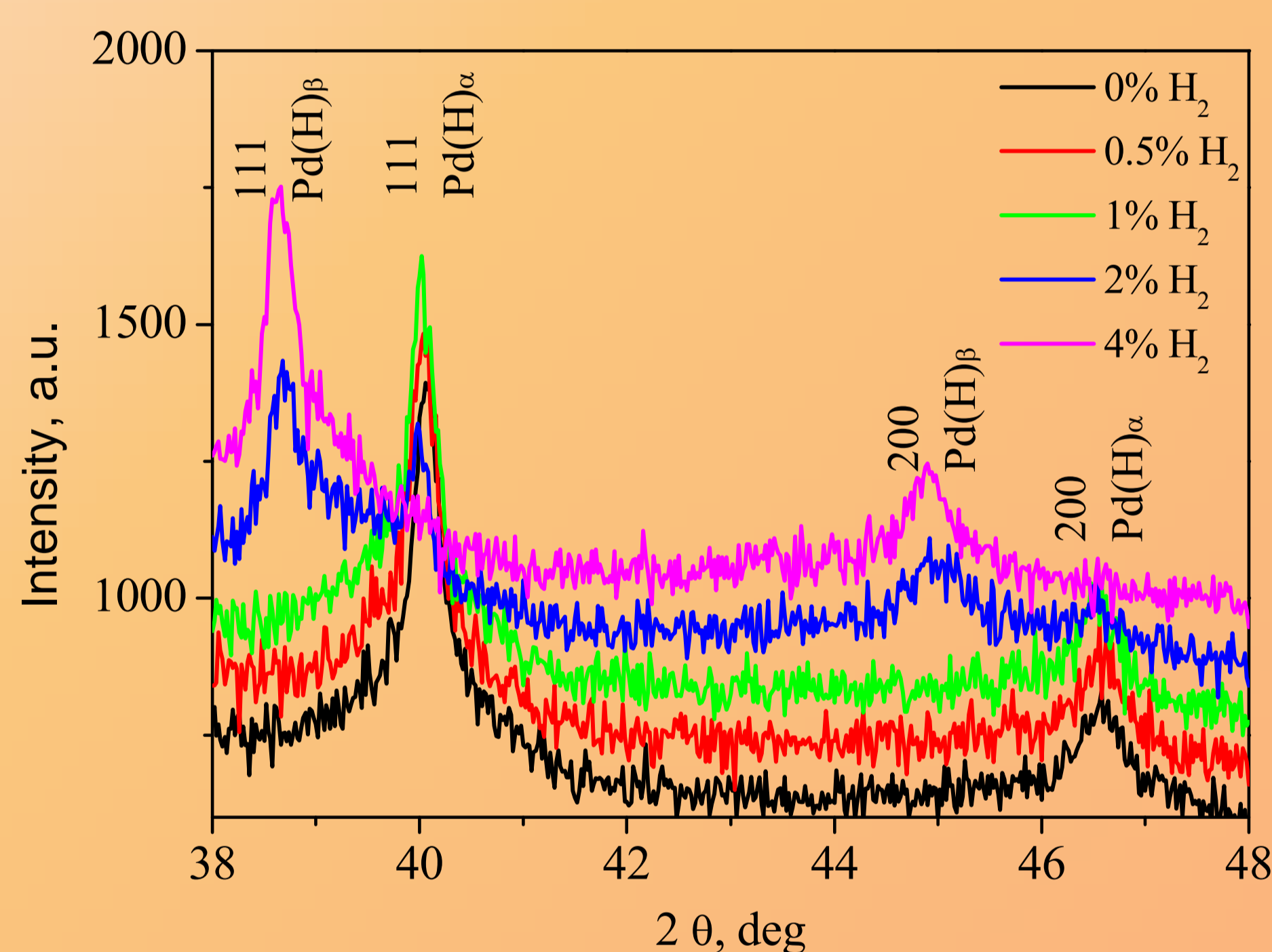


EDS spectrum



Changes in C-Pd film crystal structure under the influence of hydrogen

In situ XRD measurements

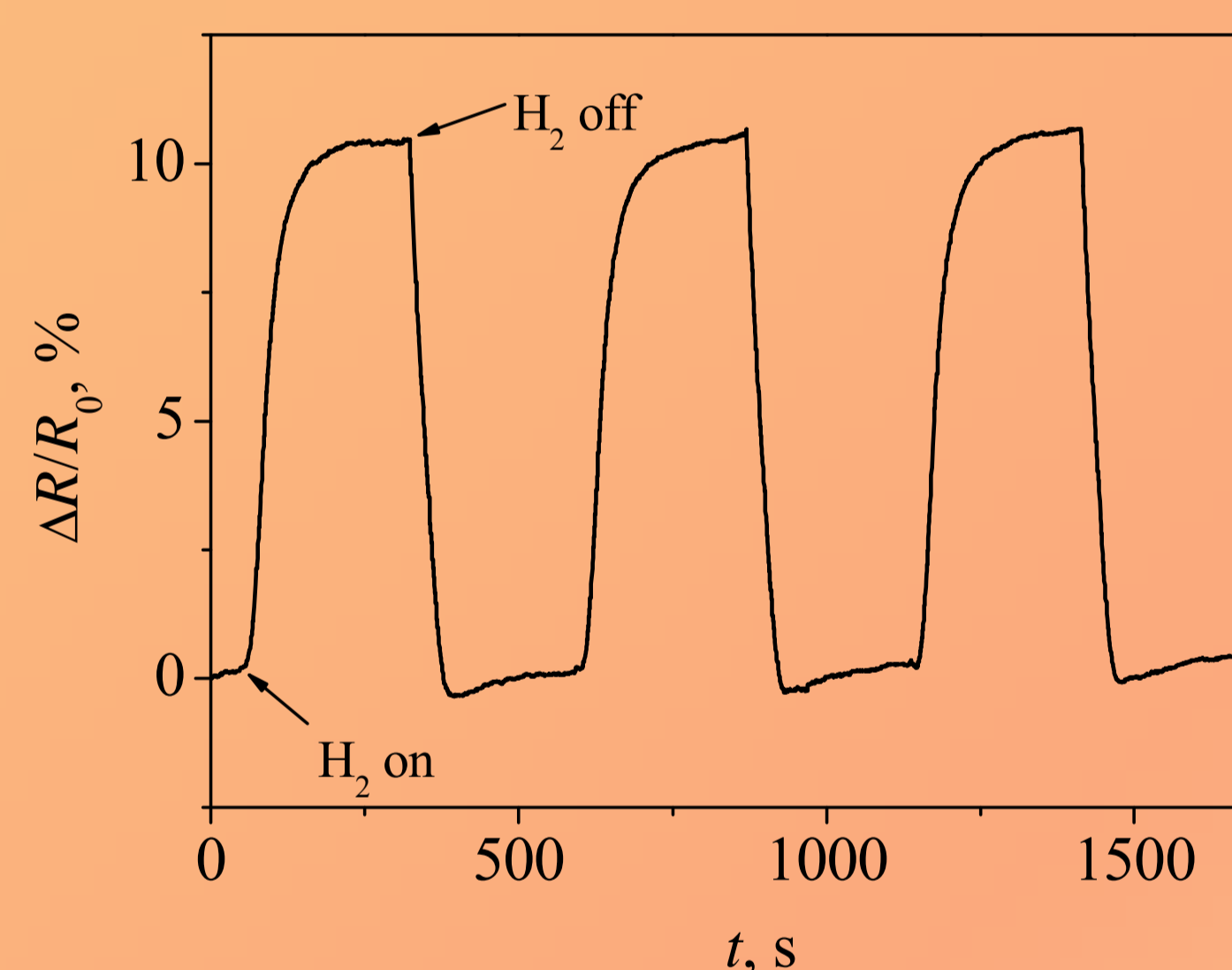


H ₂ concentration [%]	Lattice constant [Å]		
	Pd	α-PdH _x	β-PdH _x
0.0	3.8985	-	-
0.5	-	3.8998	-
1.0	-	3.9015	-
2.0	-	3.9038	4.0296
4.0	-	-	4.0357

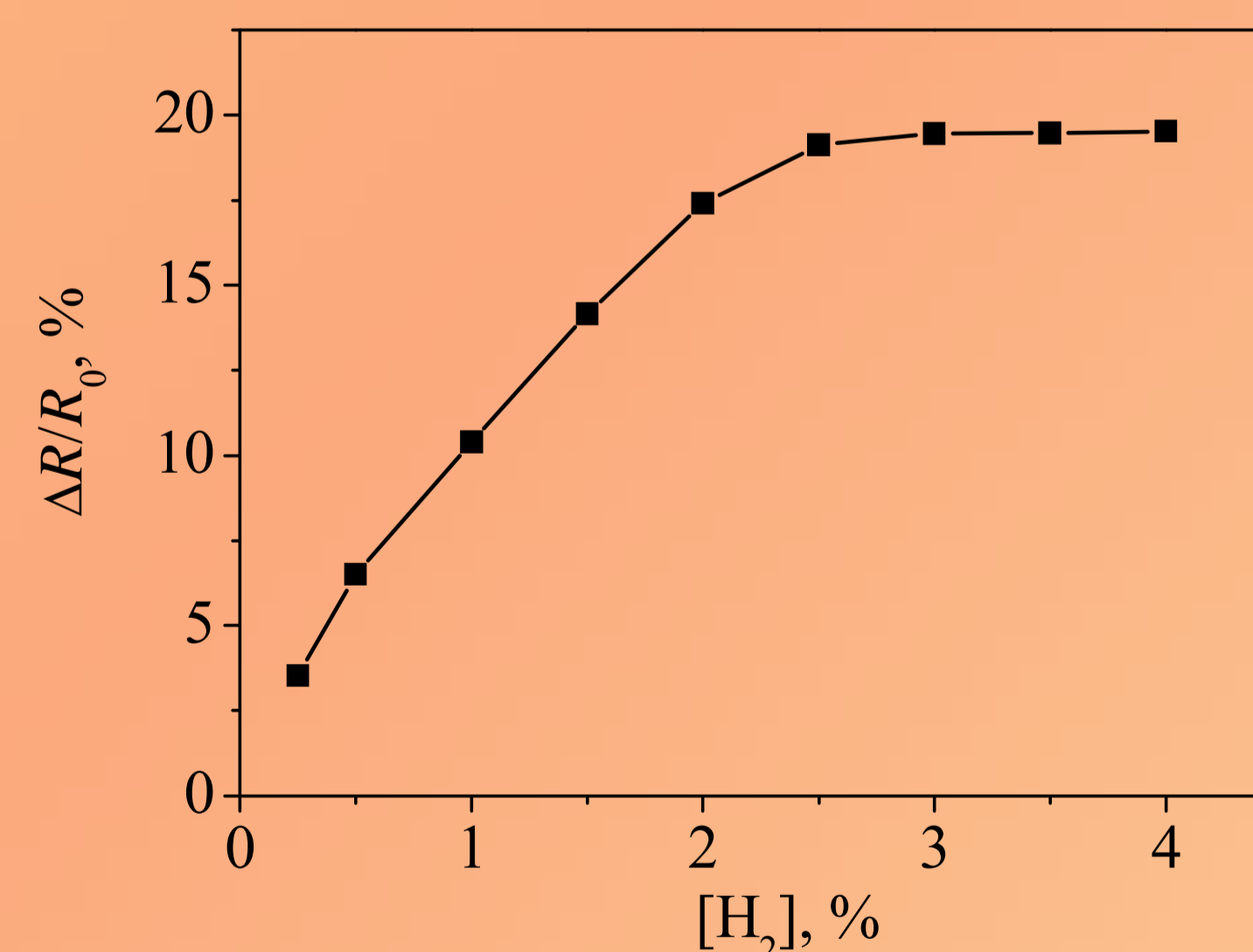
Changes in C-Pd film electrical properties under the influence of hydrogen

In situ resistance measurements

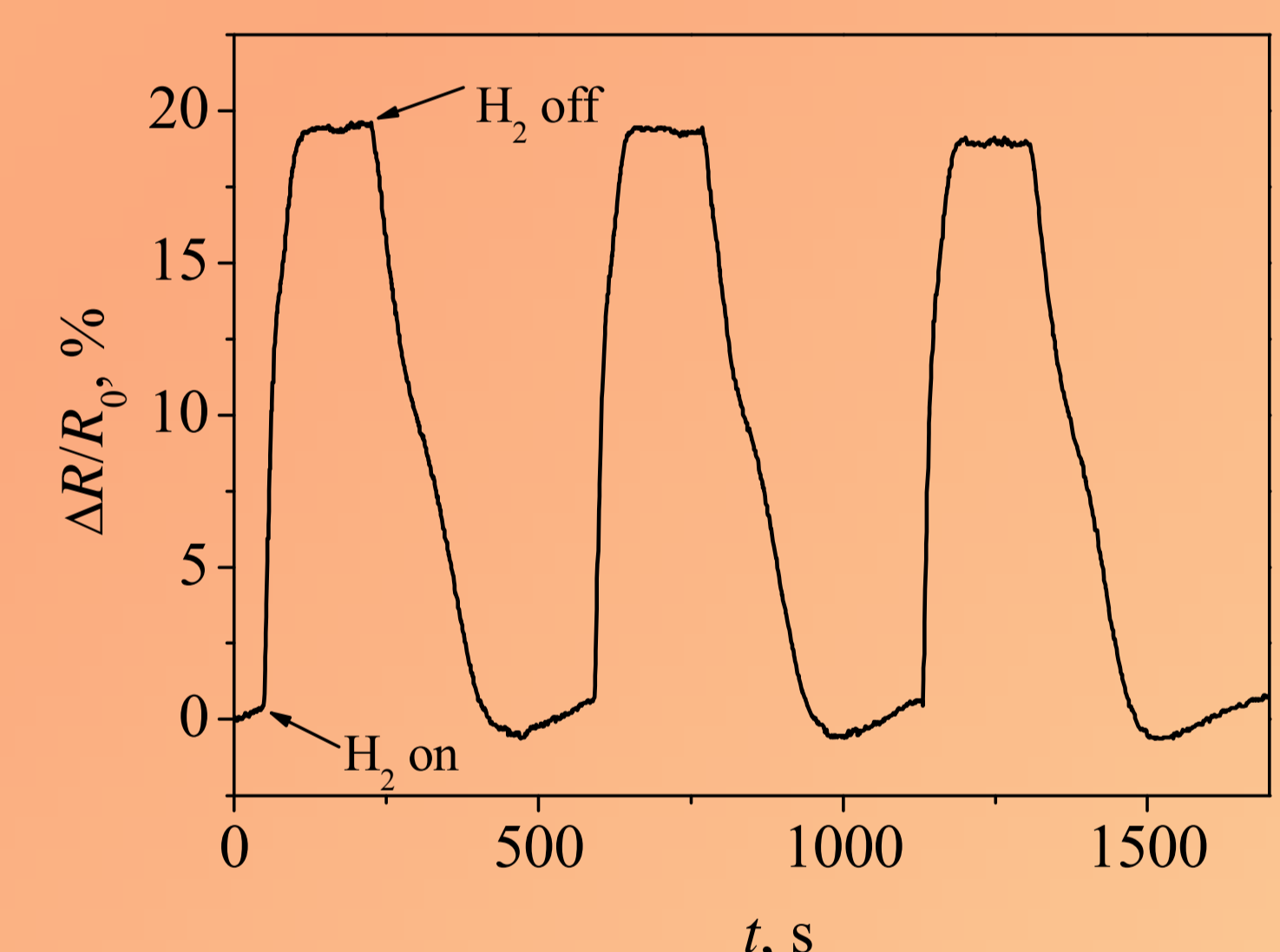
1% H₂ - α-PdH_x



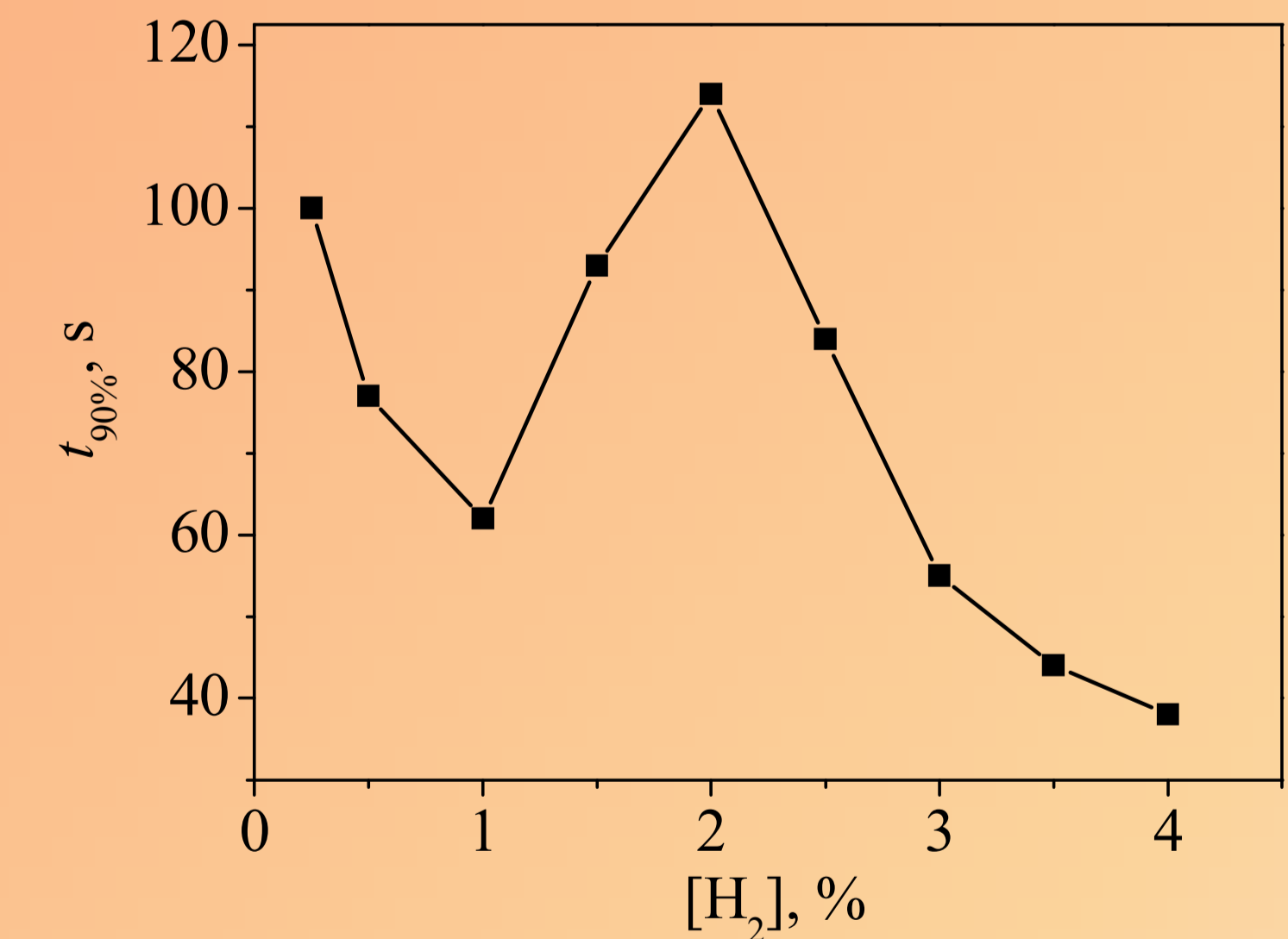
Sensitivity



4% H₂ - β-PdH_x



Response time



Conclusions

- ✓ We have correlated changes in C-Pd film sensitivity and response time toward various H₂ concentrations with the changes in the film structure.
- ✓ At lower concentrations of hydrogen (up to 2%) formation of α-PdH_x solid solution results in a linear increase in film resistance and a slight increase in the lattice constant with [H₂] increase. Exceeding hydrogen concentration of 2% leads to a phase transition α → β, accompanied by rapid increase in lattice constant, while further increase in film resistance is not observed.
- ✓ The phase transition from α- to β-phase affects the kinetics of the interaction of hydrogen with palladium, becoming the rate-limiting step of hydrogen absorption process.
- ✓ The sensing mechanism of C-Pd films is based on resistance changes due to creation of solid solution of hydrogen in the palladium.

Acknowledgements

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