# Biofunctionalization of annealed nanodiamonds

J. P. L. Gonçalves[a], M. Reitzig[a], J. Michael[b], J. Opitz[a]
[a]Fraunhofer IZFP Dresden, Maria-Reiche-Strasse 2, 01109 Dresden, Germany
[b]Technische Universität Dresden, 01062 Dresden, Germany

## ABSTRACT

In the last decades nanodiamonds have received special attention from the scientific community as a new carbon material with unique properties. Along with the macrosize diamond, those nanoparticles exhibit an exceptional hardness and $sp^3$-core whereas, the size allows different applications. Among others they can be applied in new composites, lubrication oils, polishing and electronic materials, and drug delivery, biolabeling and bioimaging systems.

To improve biocompatibility of diamond nanocrystals the surface functionalization is a favorable solution. The nanodiamonds the authors used were obtained by detonation synthesis and for this possess several functional groups on the surface. Further modifications require a homogeneous surface. In this approach a thermal methodology was used to remove the functional groups in order to produce an uniform carbon surface. The chosen biomolecules were phenylalanine, glutathione, biotin and *O*-phosphorylethanolamine to increase the biological suitability.

The thermal annealing process was performed at three different temperatures: 750 °C, 900 °C and 1100 °C, under nitrogen flow to prevent oxidation. In the end of the procedure, samples were characterized by infrared spectroscopy, thermogravimetric analysis and transmission electron microscopy.

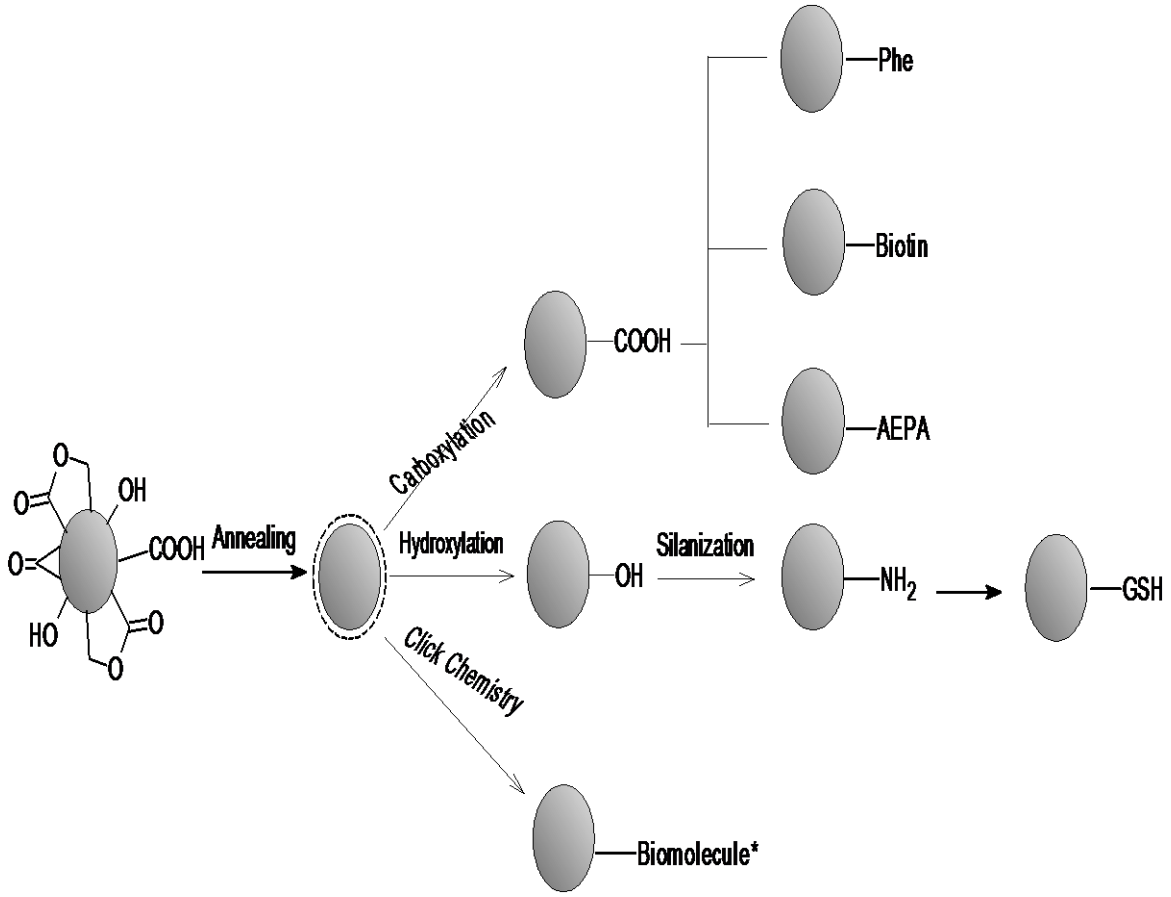


**Figure 1:** Scheme of the thermal annealing processes used

The results revealed a significant decrease in functional groups for all temperatures. At 1100 °C onion like carbon can be identified in our sample, proving of a successful graphitization of the nanodiamonds.

For biofunctionalization different approaches were applied: 1) carboxylation and further peptide bonding; 2) hydroxylation, silanization and further peptide bonding; 3) click chemistry, as depicted in figure 2.

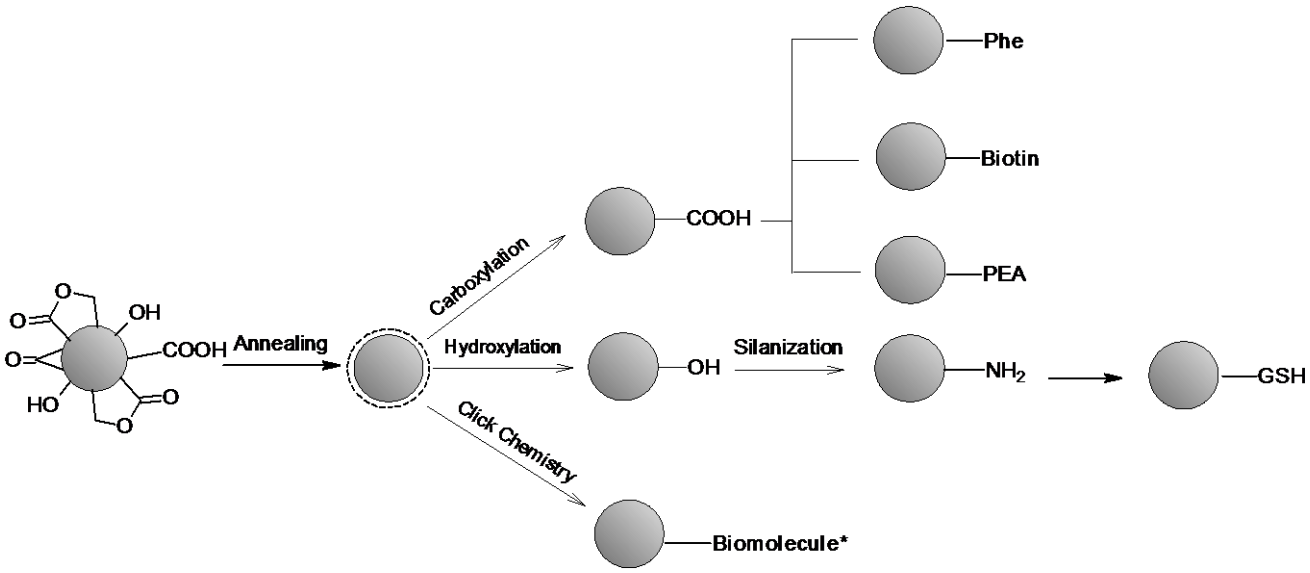


**Figure 2:** Scheme from the functionalization of the thermal annealed nanodiamonds: Phe- phenylalanine; biotin; PEA - *O*-phosphorylethanolamine acid and GSH - glutathione. On the Click chemistry methodology isopentylnitrite was used as the activation agent for the integration of the biomolecules (phenylalanine, biotin, glutathione and *O*-phosphorylethanolamine)

Success of the modification is verified by infrared spectroscopy and thermogravimetric analysis which evidence the success of the surface modification.

**Keywords:** nanodiamonds; biofunctionalization; thermal annealing; biocompatibility; nanotechnology