Size-selective Contrasting of Surface Defects using Photoluminescent Metal Nanoparticles

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Introduction

Control of pipeline corrosion is a significant problem for oil and gas industry in Russia, because equipment is operated under more and more harsh conditions, especially in regions such as Ural or Siberia. Disastrous destruction of pipelines can be prevented if corrosion is detected early by non-destructive testing (NDT) methods. There are a lot of NDT methods available for corrosion monitoring, but all of them have some drawbacks. They are not applicable for rough surfaces, contrast ability is low and a size-selective contrasting of nano-sized corrosion defects is unavailable.

Aim

The aim of the work is developing of a size-selective penetrant NDT method for pipeline surface corrosion detection.

Materials & Methods

Nanoparticles photoluminescence was induced and detected by Laser Scanning Microscope, LSM (see picture 1). Model nanocracks were etched on the surface of X70 pipeline steel specimens by focus ion beam. Imaging of nanocracks was performed using scanning electron microscope JEOL JIB-4501.

Results and discussion

In the developed method photoluminescent (PL) gold nanoparticles were used as penetrant and visual inspection of surface was replaced by mapping of nanocracks contrasted by the gold nanoparticles. The developed method was tested on model nanocracks 2500, 400, 200 and 130 nm wide. Gold nanoparticles with a diameter of 252 and 66 nm were used as a penetrant. The model nanocracks were contrasted at first with 252 nm nanoparticles, imaged, and then contrasted with 66 nm nanoparticles. SEM micrographs of the contrasted nanocracks are shown in picture 2. The nanoparticles with 252 nm diameter contrasted the nanocracks of 400 nm wide and 196 nm wide but with lower loading, and leave the nanocrack of 130 nm wide. After the confirmation of the selective filling of the nanocracks we have acquired the PL maps of the cracks (picture 3).

Conclusion

The developed method can be used for size-selective contrasting of surface defects of construction materials, in particular, for dangerous nanocrack detection on an oil and gas pipeline surface.

Acknowledgement

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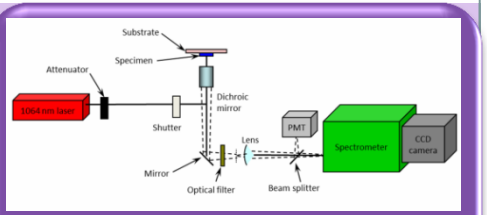
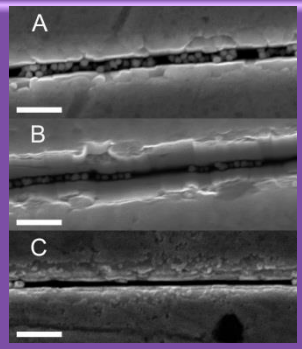
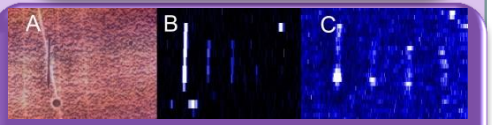


Picture 1 – Optical scheme of the femtosecond-laser scanning microscope



Picture 2 – SEM micrographs of 400 (A), 200 (B) and 100 © nm wide, contrasted with 252 nm gold NPs. Bar 1 μm



Picture 3 – Micrograph of the model nanocracks obtained with optical microscope (A), PL map of the cracks, contrasted by 252 nm NPs (B), PL map of the cracks, contrasted by 66 nm NPs (C)