TRACE LEVEL DETECTION OF EXPLOSIVES BY SURFACE ENHANCED RAMAN SPECTROSCOPY (SERS) FOR DEFENCE APPLICATIONS - BEST PRACTICE

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There is a high demand for fast, cheap and easy to use selective and sensitive methods for trace detection of explosives. SERS (Surface-enhanced *Raman* spectroscopy or surface-enhanced *Raman* scattering), is a surface-sensitive technique which is very powerful. Signal enhancement in the order of 10^4 - 10^{10} for Raman-active analytic molecules are observed and suppression of fluorescence can be achieved. It is based on the interaction between surface plasmons of silver or gold nanoparticles (10 – 300 nm) and the traces of the explosives. This poster shows invetigations concerning different parameters, like laser excitation (266 nm, 532 nm, 633 nm, 785 nm and 1064 nm), laserpower, spotsize and local energetic efficency with different available and selfmade SERS-substrates to find a best practice for an easy, effective and safe handling.

Experimental setup:

Different military used explosives (RDX, HMX, TNT and PETN) and one IED (improvised explosive devices) HMTD were tested on different SERS substrates (SERStrate Au and Ag by Silmeco, MatoS/Mato, RandaS/Randa Ag and Au by the Lituanian Laser Association, SERS Glass Slide STJ-0183-1SP/wavelet Au by S.T.Japan Inc., Klarite 303 and 305 Au by Mesophonics, RAM-SERS-Au #Au 108 by ocean optics , silver-doped polyacrylamide selfmade by ICT and a paper SERS substrate by Metrohm).

The used spectrometers are the LabRAM HR Evolution by Horiba (266 nm, 532 nm, 633 nm and 785 nm), the MultiRAM by Bruker (1064 nm) and Ventana (532 nm and 785 nm) by Ocean Optics.

The samples were mapped with different objectives (x10, x50 LWD and x100), so there are a adjusted laserpower impact on different measurement volumes on the sample surface. The SERS substrates based on different mechanisms. There are substrates with a stochastic allocation of the gold or silver nanopatter like e.g. this ones by the lituanien laser assosation (Randa and Mato). Silmeco works with gold or silver nanoparticles appliqued on a polymer mask. Metrohm and Ocean Optics paper substrates (Fig. 1) based on gold nanoparticles agglomeration or gold coating on the fibersurface of paper. The selfmade ICT-Substrates is based on insitu generated silver particles inside a polyacrylamdie matrix. But this is by far not all, there are a lot of other principles of operation for the enhancement.

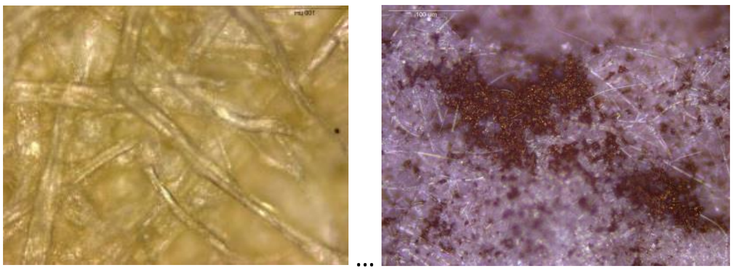

Fig. 1: Metrohm (gold coated) and ocean optics (gold agglomeration) paper substrates, 20x objective,

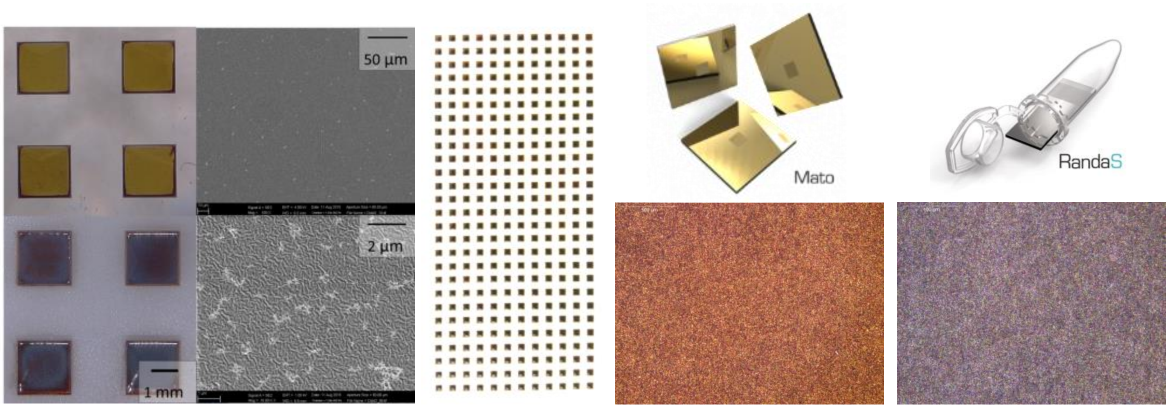

Fig. 2: Selfmade ICT-SERS-Substrate, Mato Au Randa/S Ag - by the Lituanian Laser Association,

The ICT-SERS substrate (Fig. 2) based on a acrylamide matrix, silver particeles are formed inside by reduction of silver nitrate. There is an automated fabrication with a dosing module, so a production of 10 arrays with 324 separate spots a day is possible. The production is quickly and cheap, the arrays have a long livetime and a reproducible enhancement arround 10^7.

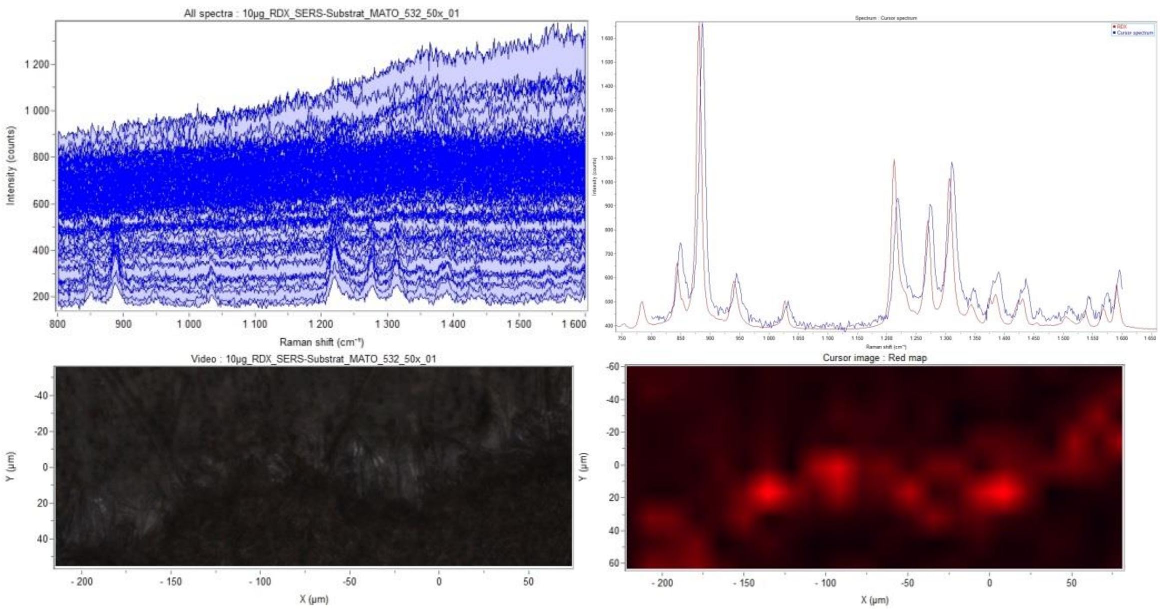

Fig.3.: 10 µg RDX on a Mato Au - by the Lituanian Laser Association, spectra of the mapping region (top left) and integration distribution of the RDX molecule vibrations with a library comparison (right top)

Figures 3 shows an example of a mapping fom 10 µg RDX on a SERS-substrate (Mato Au by the lituanian laser assosiation), the Raman spectra in the region from 800 cm^{-1} to 1800 cm^{-1}, additionaly to the photograph from the mapped area ther is a falsecolour picture of this area. Red colour means regions with RDX and black means the field of the matrix without RDX, you can also see a comparision with a library spectra of RDX. The sample was measured wit an laser excitation of 532 nm, an 50x LWD-objectiv with a laserpower o 10 mW. On figure 3 you can see pictures from the SERS substrates surfaces.

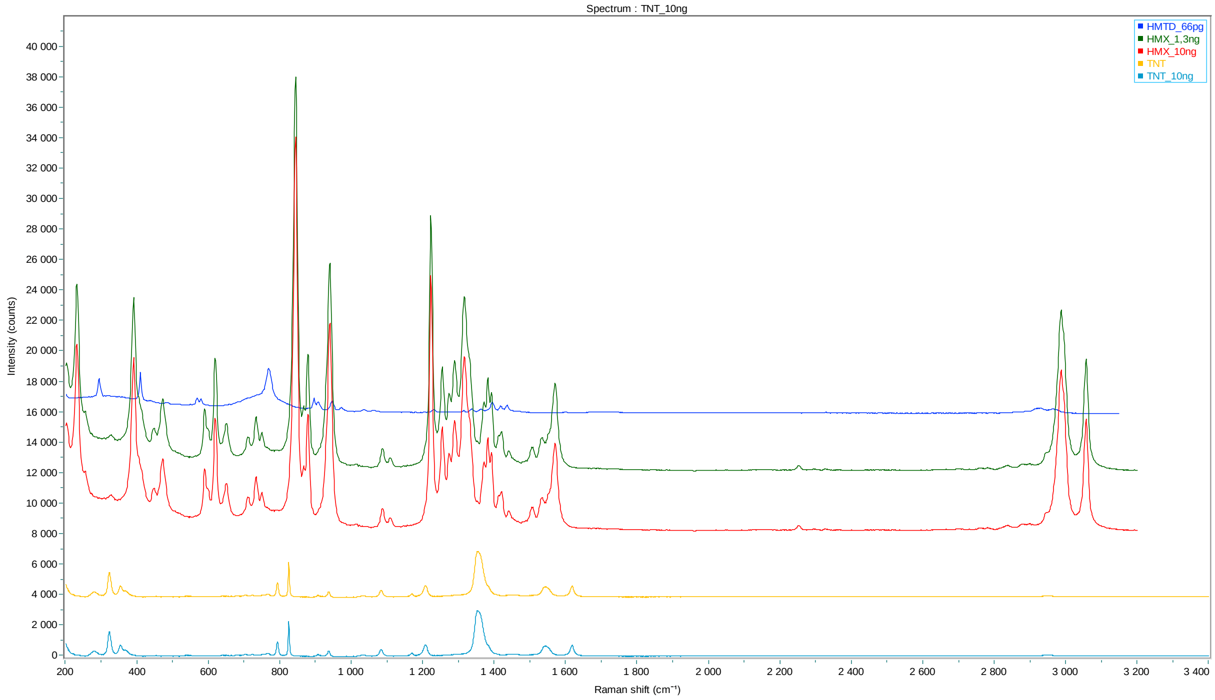

Fig. 4 Trace detection (different amounts) of improvised and military used explosives (e.g. HMX, HMTD and TNT) on different silver-SERS substrates with a laser excitation of 532 nm, 100 x objectives

Figure 4 present a comparison from spectra of different explosives on a simple silver coated aluminum substrate, it was measured with a laser excitation by 532 nm, a 100x objective and a laser power around 10 mW.

Best results for silver coated substrates were shown with the 532 nm laser; substrates with gold nano structures have an enhancement with a laser excitation by 633 nm and 785 nm, however they have also a good enhancement with the green laser (532 nm). An excitation in the UV-region works with aluminum- or gold/palladium substrates. Different substrates enhance different molecule vibrations, specific functionalization of the surface could be used for selectively detection. There is an immense influence of the size and the arrangements of the metal nano particles on surfaces with the excited wavelengths of the laser, this will be tested further in future research activities.