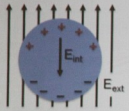
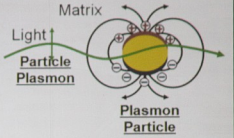
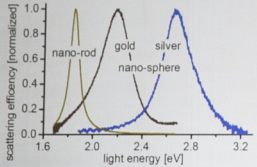
Nanoplasmonics: Particle Plasmons – what are they?



The objects of nanoplasmonics are collective oscillation of the conduction electrons, strongly influence on the optical properties of metal nanostructures.

The penetration depth of light waves in noble metals is about 30 nm and the excitation light is able to penetrate the nanoparticles





The nanospheres of noble metals (Au, Ag) with diameter smaller than 50 nm are the most famous objects of nanoplasmonics.

The resonant excitation of a collective oscillation of band electrons in such particles is called Particle Plasmon or localized surface Plasmon.

The particles with resonant excitation are called Plasmon Particles.

Optical properties of such particles are determined by size, shape and environment

The historical applications of Particle Plasmons

Bright color
of gold and silver nanoparticles
have fascinated people
for many centuries

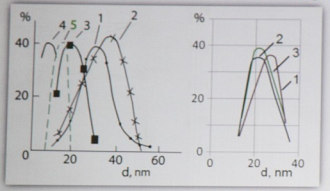
Lycurgus cup, 4th century AD
(now at the British Museum, London).
The color of this cup is determined by nanoparticles of Au-Ag embedded in the glass.

The stars of Moscow Kremlin, 1937.
The color of this stars is determined by nanoparticles of Au-Se embedded in the Ruby-glass.

Lippmann fine-grain emulsions is the base of Denisyuk's holograms

Particle size distribution

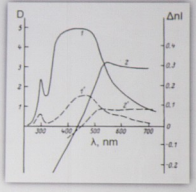
AgHal **Ag**



Y.Usanov, et. al, 1977

1. Mus K., 1949
2. Yaroslavskay N., 1976
3. Ryabova R., 2007
4. Yves Gentet, 2007
5. Poure distribution NPM-17

Optical properties of developed AgHal-photoplates for display holography



Nanoparticles of developed silver form strong modulation and high transparence holograms at long wavelenth visible region

O.Andreeva, et. al, 1984

Wonderful holograms produced in accordance with Denisyuk's method



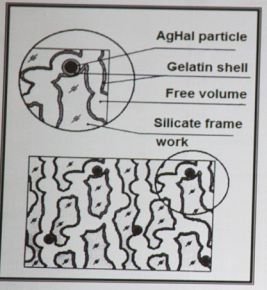
Excibition of holograms

Minsk -1978
Sankt-Peterburg -2005
Praga - 2007
Minsk, 2012
Astana, 2014
Optics museum of IFMO - 2015


These display holograms have been recorded on AgHal photoplates

What's next?

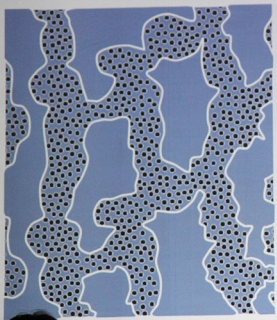
AgHal-lightsensitive medium for recording volume holograms based on nanoporous matrix (AgHal-NPM)



- The thickness of AgHal NPM ≈ 1 mm, while the thickness of AgHal photoplates ≈ 10 mkm
- Diameter pores, d ~ 17 nm

- The volumetric concentration of silver ~ 0.1%
- The surface mass of developed silver M = (1-5) g / m

1. Porous sample NPM-7



Treatment in acid.

The average pore diameter is 7 nm

2. Lihgt-sensitive AgHal-NPM medium

Treatment NPM-7 in alkali solution.

The average pore diameter is 17 nm

The free volume is about 50%.

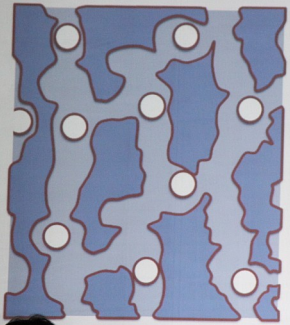
3. Lihgt-sensitive AgHal-NPM medium

The gelatin solution fills free volume

3. Lihgt-sensitive AgHal-NPM medium

The synthesis of AgHal paticles

3. Lihgt-sensitive AgHal-NPM medium



The sample have a network of through capillaries for post-exposure treatment

The specific properties of AgHal-NPM

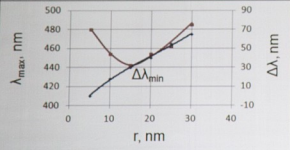
- high physical and mechanical performance;
- geometrical dimension of the AgHal samples remain unchanged in the region of space less than light wavelength;
- the size of the light-sensitive and developed particles cannot exceed the maximum size of porous framework ducts; such as, the size of particles are less than 20 nm;
- post-exposure treatment is performed with the using of traditional photochemical solutions owing to the presence of through capillary network.
- Ag particles formed inside NPM have an absorption spectrum with maximum efficiency and minimum width.

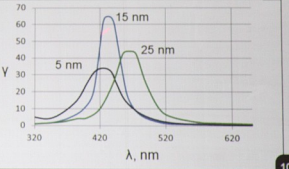
The application

- High selectivity hologram optical elements with physical and mechanical properties similar to the ones of silicate glass
- (Spectral selectivity is about tenth milliradian; angle selectivity is about tenth nanometer)
- Devices of long-term Information storage

The advantage of AgHal-NPM is the following:

Holography	Nanoplasmonics
Generation of volume holograms with strong phase modulation and small absorption in the long-wave visible spectral regions, having physical and mechanical properties close to silicate glass	The new materials and elements with unique specific properties: Negative-Index Metamaterials Epsilon-Near-Zero Applications High-Fiigure-Of-Merit





Conclusion:

Nanoplasmonics
The beginning – 1-IV century AD
Fast development – XXI century

Display holography
The beginning – 1948-1962
Fast development – 65-90 years of XX century

The new materials and elements with unique specific properties

Silver nanospheres connect two branches of physic.
(The main reason is optical properties)