Spherical Targets Preparation technology (Filling and Characterization) for Laser Experiments.

A.I.Nikitenko, I.E.Osipov, S.M.Tolokonnikov.



Neutron-physical department Thermonuclear Targets Laboratory LPI, Moscow.

Two technologies for ICF targets preparation and inspection are discussed





Shells filling up to high pressure

Targets and shells inspection and characterization. Other objects.



High pressure filling system - specification

- Gas type	H ₂ , D ₂ ;
- Maximum working pressure	1000 atm;
- Maximum pressure inside shells	600 atm;
- Temperature in the filling chamber	300-650 °K;
- Pressure/temperature measurement accuracy	±0.5%;
- Filling chamber volume	20 cm ³ ;
- System is fully controlled by computer;	
- Programmable pressure/temperature control	
to protect shells destruction;	
- Compact design:	
- size	845X702X520 mm;
- weight	< 100 kg;
- nominal power	900 W.



High pressure filling system – diagram





High pressure filling system – detailed views











High pressure filling system – cassettes for shells





Optical characterization: problems, fields of interests.

1. ICF targets characterization.

- information extraction from shadowgraphs images of ICF targets and shells;

- optical control methods for targets technology development;
- precise methods of different targets measurements according their images;
- spherical targets shape 3D reconstruction methods;
- threshold characterization;
- targets image formation modeling.
- 2. Material structure analysis according their images. Powder materials.
 - granulametric analysis;
 - inclusions distribution in solid and porous materials;
 - shape, size and distribution of crystalline grains;
 - AFM and SEM "images" processing and analysis.



Typical images for the analysis.



Shells' array



Shell (polystyrene)



Mounted target



Cryogenic target



Shell's interference image



Nanoparticles



Target's surface (AFM scan)





Metal powder

Practical solutions

Microscope + high resolution CCD-camera + computer + specialized software



Results' adoption

- measurements of object's physical parameters;
- shells selection for ICF targets;
- targets certification;
- technology improvement, optimal technology parameters search;
- statistic;
- detailed objects examination.

Software construction

1. General.

- all developments are delivered to users in the form of the ready software product supplied by the necessary documentation and built-in help system;
- operating system Windows XP;
- programming language C^{++;}
- distribution installation package or preset at the stand
- support and updating.
- 2. Main stages of object image processing.
 - image improving without information losses, allocation of areas of interest, scaling, etc;
 - automatic objects search, image segmentation;
 - analysis of all chosen objects (size, shape, position, etc., statistics of objects);
 - search of the specified objects, sorting of objects on classes, removal of background objects (dust, scratches and so on);
 - detailed analysis of the chosen object, its characteristics measurement;
 - results visualization 2D и 3D plots, histograms, tables, presentation in conditional colors and so on;



- saving and accumulation of results - record in a file, preservation in a database, printing and so on;

Preprocessing

- 1. Image filtration.
 - traditional filters (Gauss, median etc.);
 - adaptive filters (Wiener);
 - wavelet filtration (undecimated wavelet transform, wavelet packages);
 - ridgelet and curvelet filtration, wavelet pyramid in Fourier space.





Original image

Ridgelet filter application

Curvelet filtration

- 2. Intensity flatten out.
 - automatic Gauss pyramids, wavelet pyramids;
 - semi automatic according sample areas (intensity distribution approximation with 2D function);
 - according background image.





Objects detecting

- 1. According their contours, contours obtaining.
 - 2D differentiation;
 - Sobel transform;
 - Teager energy;
 - nonmaximal suppressing;
 - contour curvature analysis;
 - contours separation and merge.



- 2. According relative intensity.
 - threshold cutting;
 - modified watershed algorithm
 - Teager energy map and dispersion map using.









Objects analysis and measurement

- 1. Precise measurements of the shells.
 - Polar system coordinate transition;
 - edges and maxima search by Levenberg-Marquardt method;
 - iterational refinment;
 - Fourier analysis (Power spectra).

 $R_{out} = 676\mu$ $R_{in} = 633\mu$ $D = 43\mu$







- 2. Objects statistic.
 - sizes;
 - shape;
 - orientation;
 - position, distribution on image.







Sorting and search of objects

Objects descriptors.

- central moments;
- Hue moments;
- Fourier descriptors;
- wavelet descriptors;
- shape similarity Euclidean distance between vectors-descriptors.









Application

- ICF targets technology (LPI, Moscow).

- Technological and precision measurements of targets parameters for laser experiments. (VNIIEF, Sarov).

- Development of spherical BeD targets fabrication technology and powder materials analysis. (VNIINM, Moscow).





A.I.Nikitenko

