

**PANDA DIRC  
bar production  
at Lytkarino – Dubna**

## **Two stage of the PANDA DIRC bar prototypes production:**

- **10 short bars (300 mm) from Russian fused silica «KS-4V»**
- **4 long bars (900 mm) from fused silica «Spectrosil 2000». Blanks were delivered by Saint Gobain Quartz PLC (now Heraeus Quartz UK Ltd)**

# Polishing was made at Russian Enterprise "Lytkarino Optical Glass Plant"

Production area





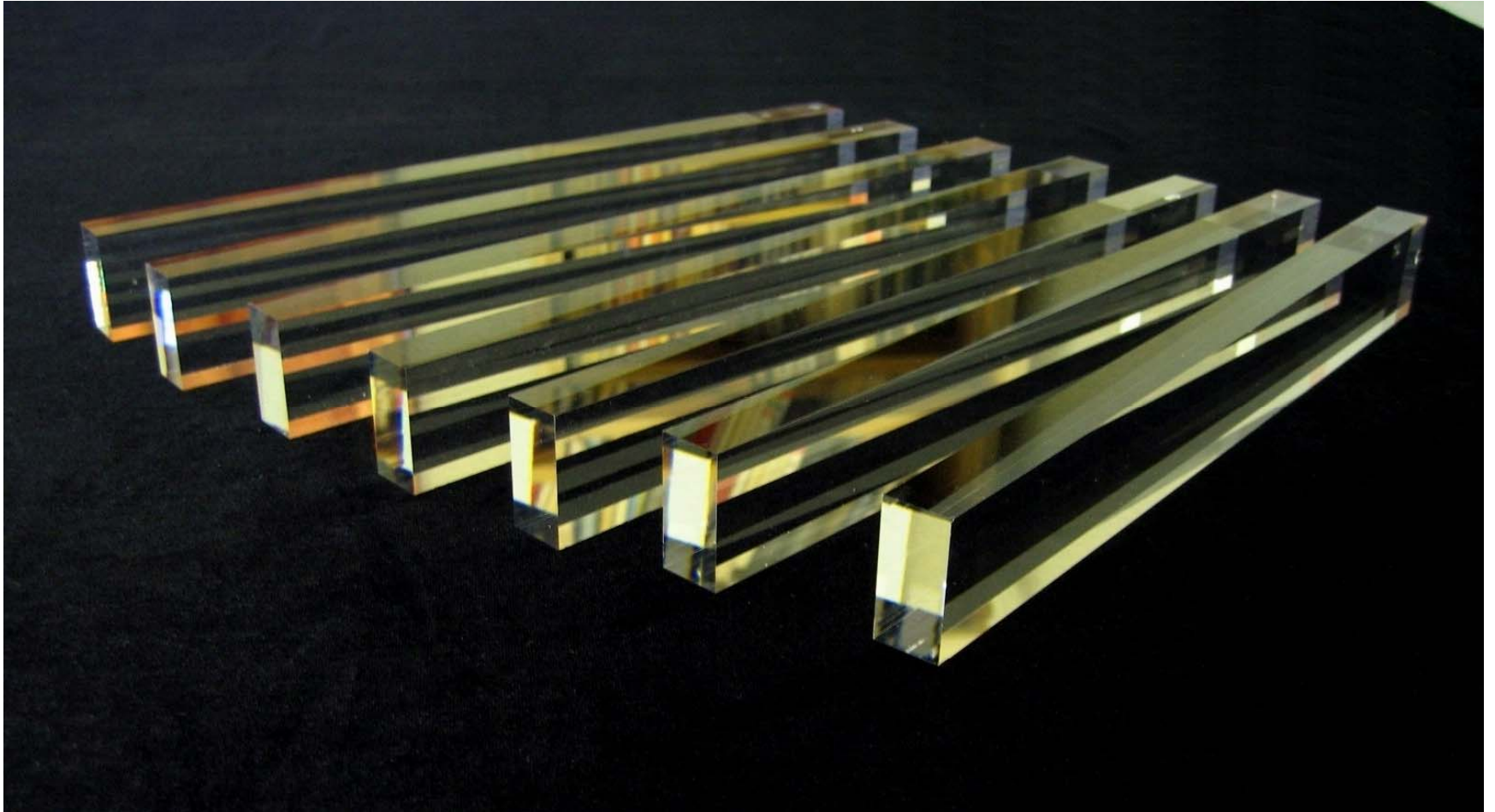
**Big polishing machine to treat 6 m optic ware with accuracy ~ 1 nm**





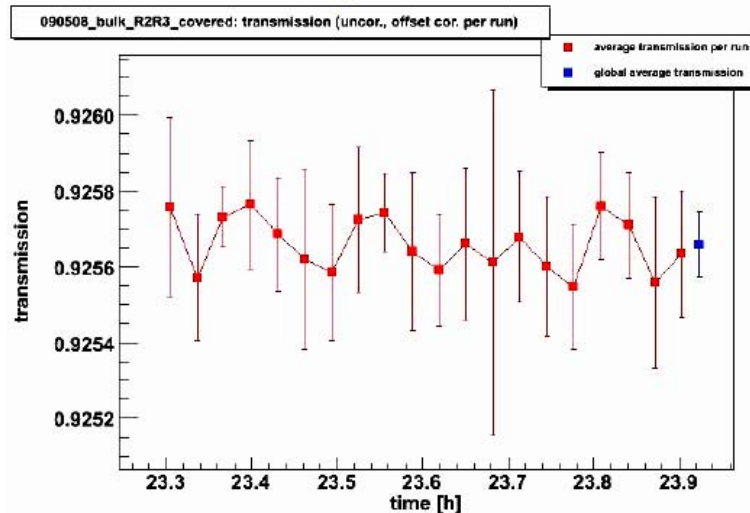


# 300 mm short bars



# 300 mm short bars

## Preliminary results (Russian)



$$T = 0.9257 \pm 0.0001$$

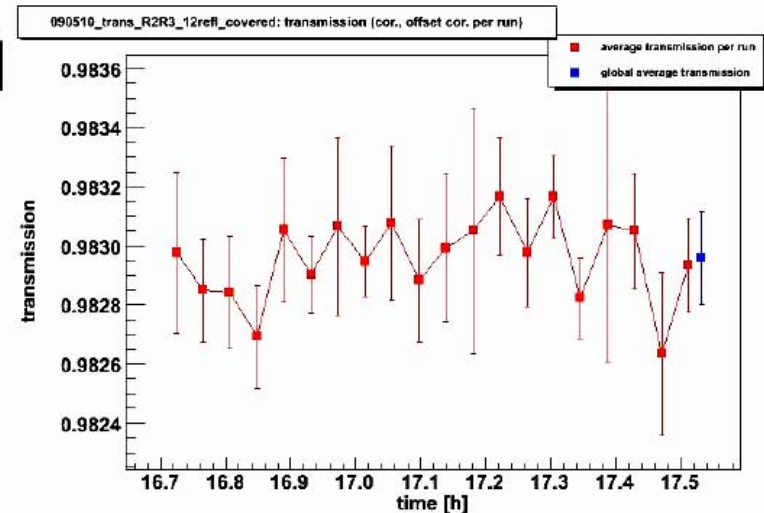
only stat. error

transmittance per m (fresnel corrected):

$$T_{\text{cor/m}} = 0.9915 \pm 0.0002$$

attenuation length:

$$\Lambda = 117.6 \pm 2.1 \text{ m}$$



$$T = 0.9830 \pm 0.0002$$

only stat. error

reflection coeff. (12 reflections):

$$R = 0.99915 \pm 0.00002$$

roughness:

$$\sigma = 21.8 \pm 0.3 \text{ \AA}$$

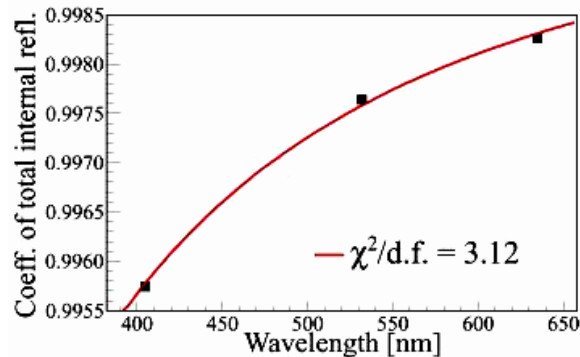


# 300 mm short bars

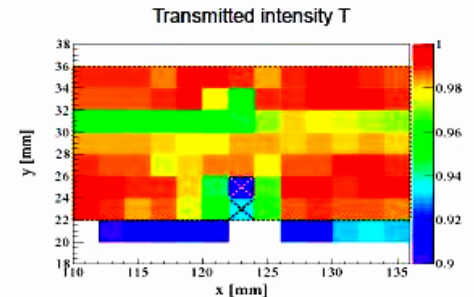
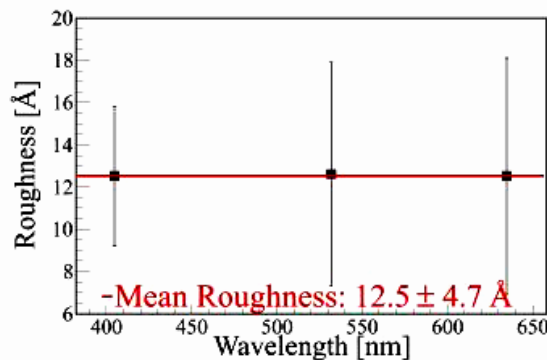
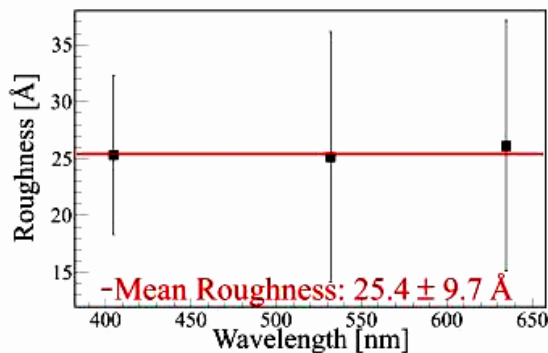
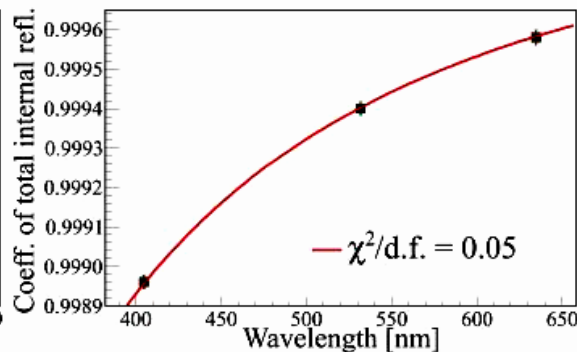
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## Radiator Quality Test Results: Lytkarino LZOS, 30cm bar

6 Reflections



12 Reflections



- Results consistent with the specifications.
- Some bar defects.
- Short length of the bar.
- New 90cm length prototype bars from LZOS almost done (update on delivery and manufacturer's QA data at April DIRC workshop)

# 300 mm short bars

Miass "R1"

"R2"

$$\delta\theta_1 = 5.54$$

$$1.23$$

$$\delta\theta_2 = -5.33$$

$$-1.12$$

$$\delta\theta_3 = 5.54$$

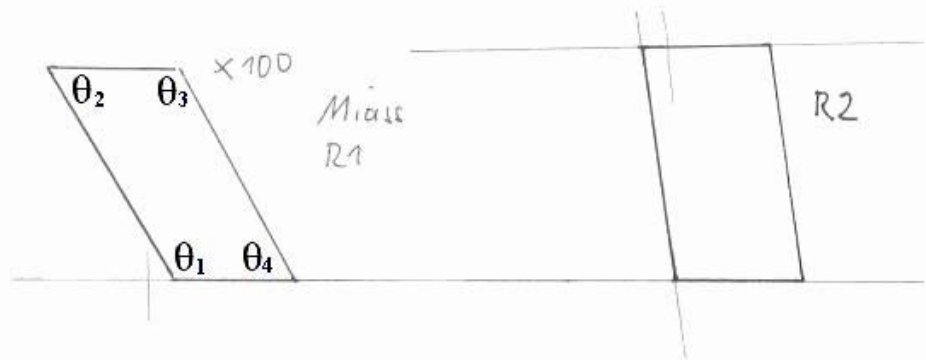
$$1.12$$

$$\delta\theta_4 = -5.75$$

$$-1.23$$

$$\pm 0.03$$

$$\pm 0.05$$



1. Results consistent with the specifications
2. Shape defect that was detected during the quality control

## **900 mm long bars**

### **Fused silica bulk material quality:**

**Our requirement to**

- optical homogeneity of the fused silica bulk material,**
- homogeneity of the refractive index in the batch of the fused silica blanks,**
- homogeneity of the average dispersion in the batch of the fused silica blanks,**
- transmission,**
- birefringency category**
- bubbles, inclusions, striae etc ...**

**were defined during negotiation for the St. Gobain contract according with standards, high but possible critical quality performances.**

## **900 mm long bars**

**Problem of mutual understanding was facilitated especially because there was kept some experience of collaboration with BaBar**

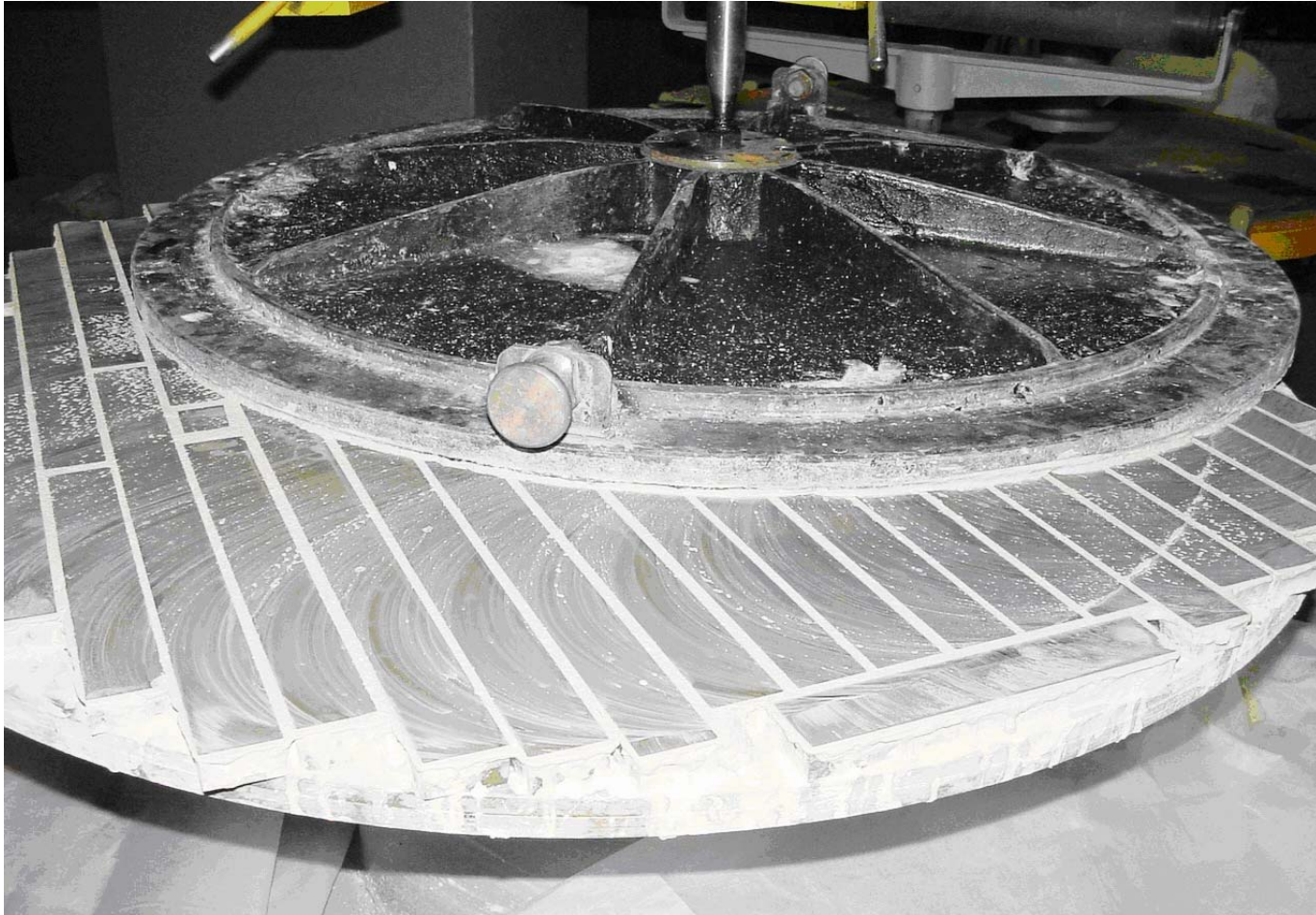
**4 bar blanks from Spectrosil 2000 fused silica were delivered by St. Gobain**

# 900 mm long bars

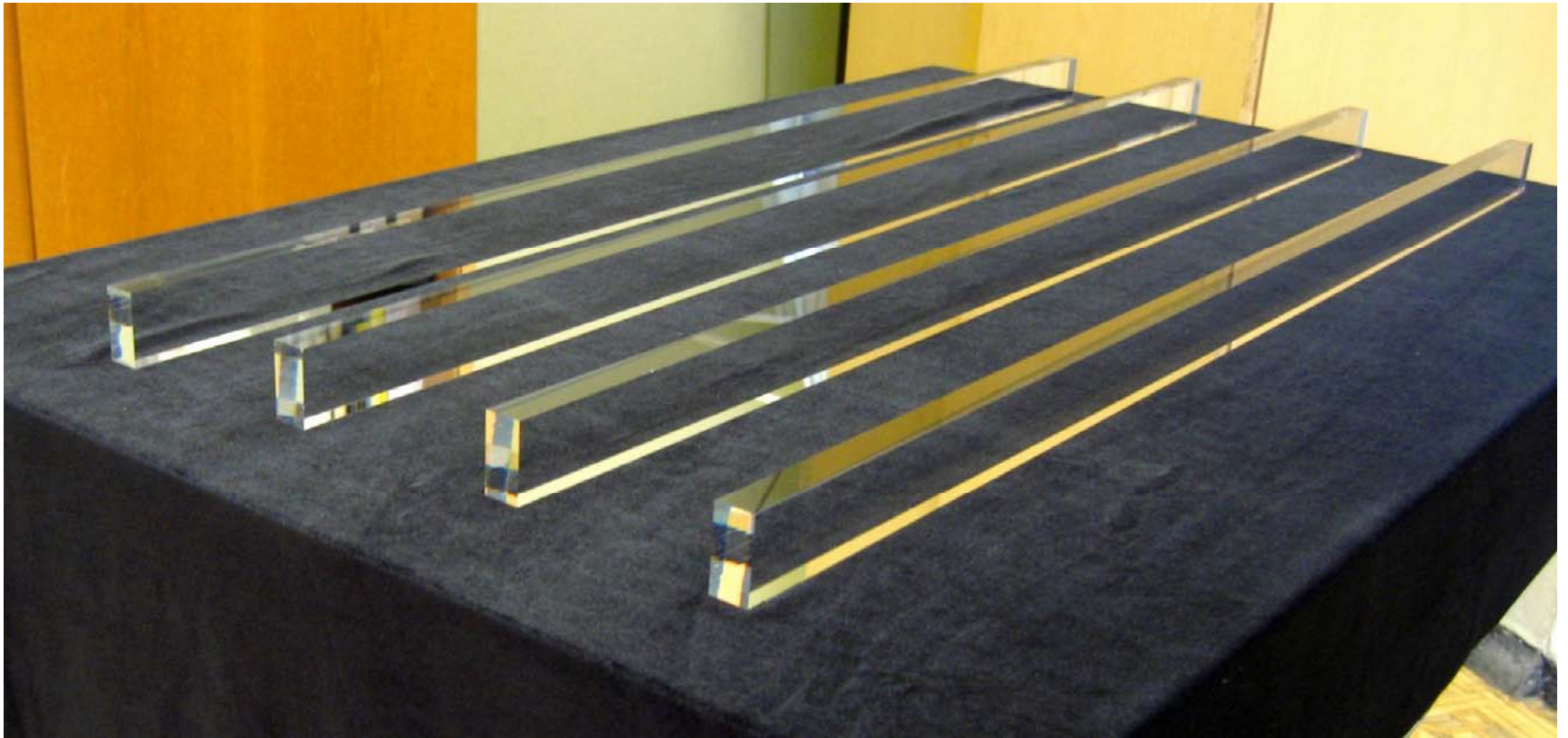




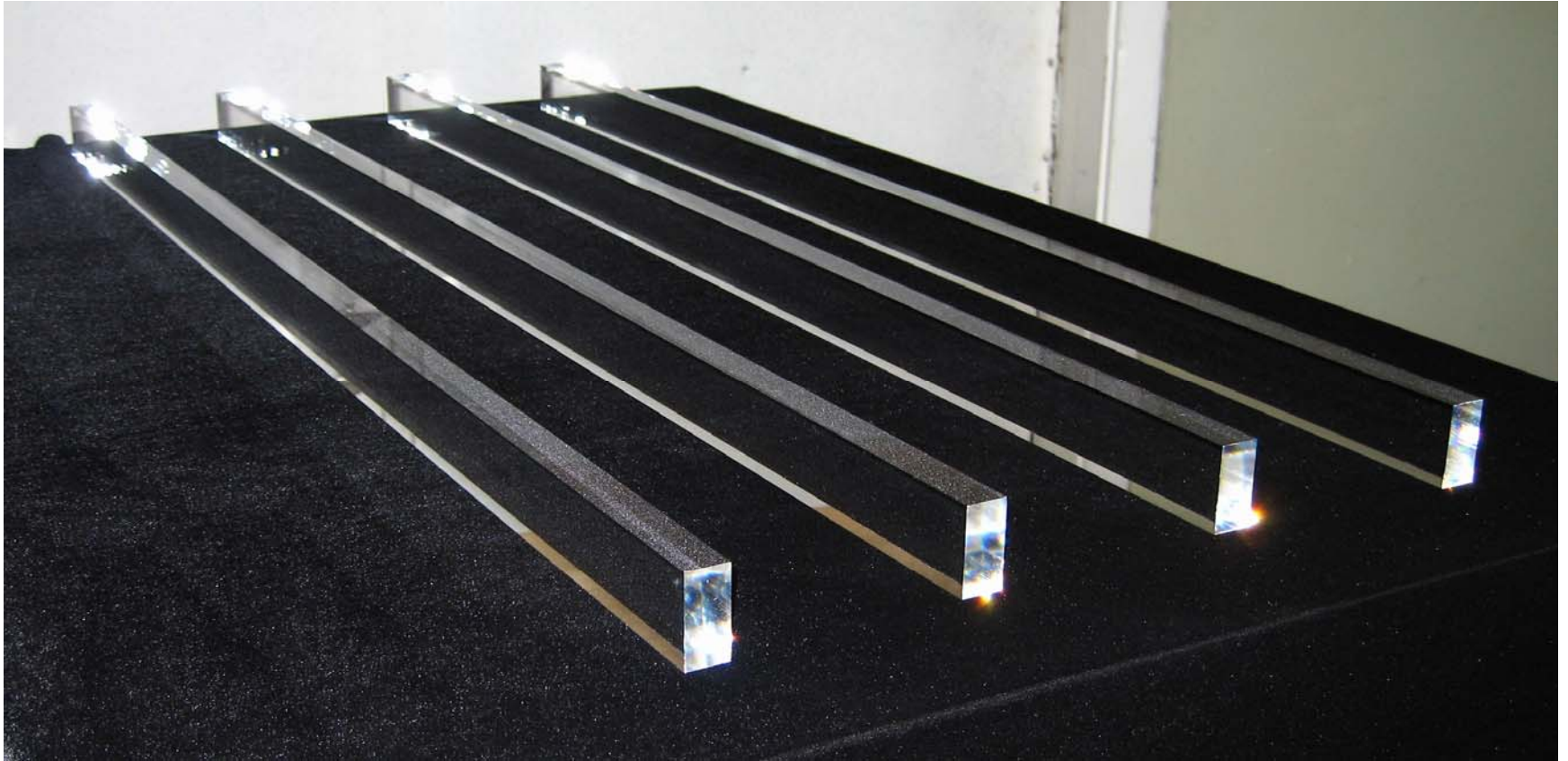
# 900 mm long bars



# 900 mm long bars



# 900 mm long bars





## **900 mm long bars**

### **Physical dimensions specifications:**

- **The dimensions for all pieces shall be identical to a tolerance of 0.5 mm absolute. In addition, in groups of two bars, the widths shall be identical to 0.05 mm with a goal of 0.025 mm, and the thickness identical to 0.25 mm with a goal of 0.025 mm.**

# 900 mm long bars

## Physical Dimensions

<b>N<sup>o</sup></b>	<b>900<sup>+0.000</sup><sub>-0.500</sub> mm</b>	<b>35<sup>+0.000</sup><sub>-0.500</sub> mm</b>	<b>17<sup>+0.000</sup><sub>-0.500</sub> mm</b>
<b>1</b>	<b>899.5</b>	<b>34.8</b>	<b>16.7</b>
<b>2</b>	<b>899.5</b>	<b>34.8</b>	<b>16.7</b>
<b>3</b>	<b>899.6</b>	<b>34.8</b>	<b>16.7</b>
<b>4</b>	<b>899.6</b>	<b>34.8</b>	<b>16.7</b>



# 900 mm long bars

## Parallelism and Flatness specifications

- The sides / faces shall be parallel to 0.025 mm.
- The bar faces shall be flat to 0.1 mm max.
- The bar sides shall be flat to 0.025 mm.
- They shall be flat to 0.0025 mm over any 25×25 mm<sup>2</sup> area.

# 900 mm long bars

## Parallelism and Flatness

<b>№</b>	<b>35×900 mm</b>	<b>17×900 mm</b>	<b>17×35 mm</b>	<b>Newton rings for Ø30 mm</b>
<b>1</b>	<b>0.03</b>	<b>0.03</b>	<b>0.02</b>	<b>1 ~ 0.275 MKM</b>
<b>2</b>	<b>0.03</b>	<b>0.03</b>	<b>0.02</b>	<b>1 ~ 0.275 MKM</b>
<b>3</b>	<b>0.03</b>	<b>0.03</b>	<b>0.02</b>	<b>1 ~ 0.275 MKM</b>
<b>4</b>	<b>0.03</b>	<b>0.03</b>	<b>0.02</b>	<b>1 ~ 0.275 MKM</b>

## **900 mm long bars**

### **Surface quality specifications:**

- **The surface finish of the sides and faces shall have a surface roughness of 10 Å *rms* or better.**
- **The surface finish of the ends should have a surface roughness of 20 Å *rms*.**

# 900 mm long bars

## Roughness measurements

- roughness of specimens-“witnesses” was measured by scanning probe microscope “NTEGRA- Prima”
- the specimens-“witnesses” -  $10 \times 10 \times 7 \text{ mm}^3$ , corresponded to different quartz bar sides and different polishing stages
- for every samples the atomic-force images of  $60 \times 60 \text{ }\mu\text{m}$ ,  $30 \times 30 \text{ }\mu\text{m}$ ,  $10 \times 10 \text{ }\mu\text{m}$  and  $5 \times 5 \text{ }\mu\text{m}$  were obtained.

### Образец № 1 Вторая точка.

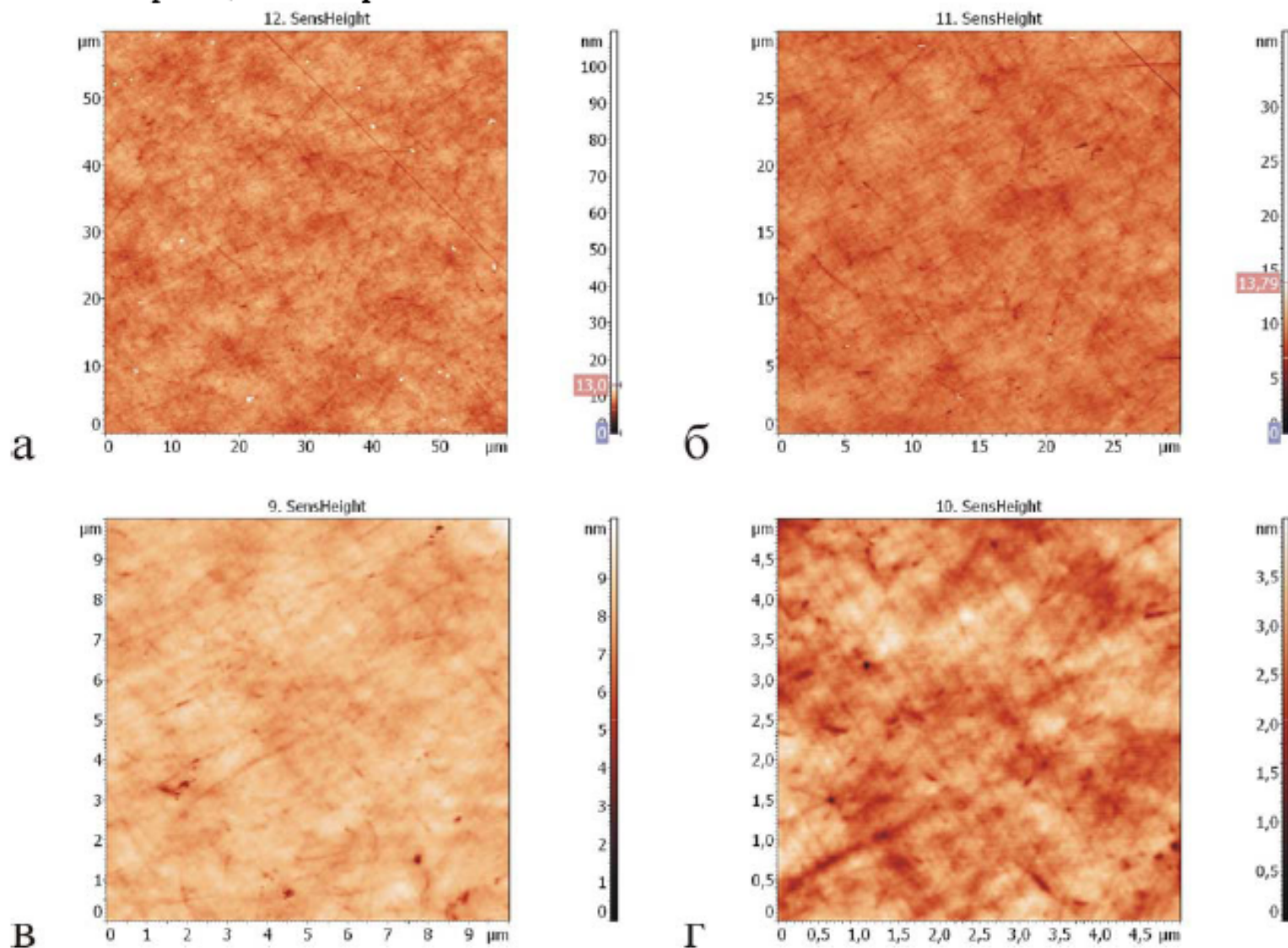
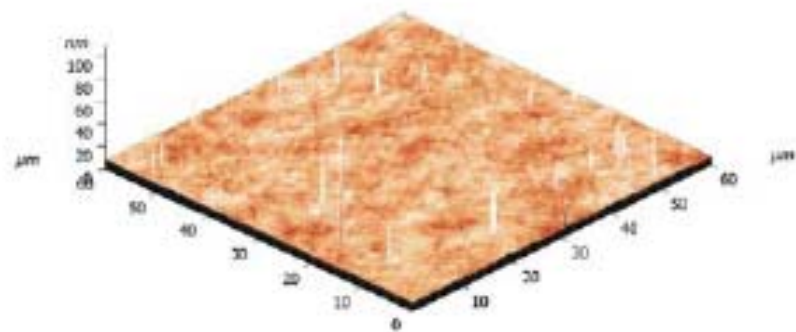
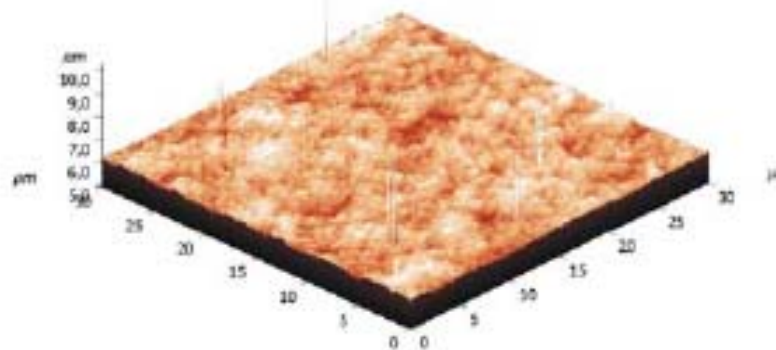


Рис. 3. 2D АСМ изображения поверхности образца №1 во второй точке.

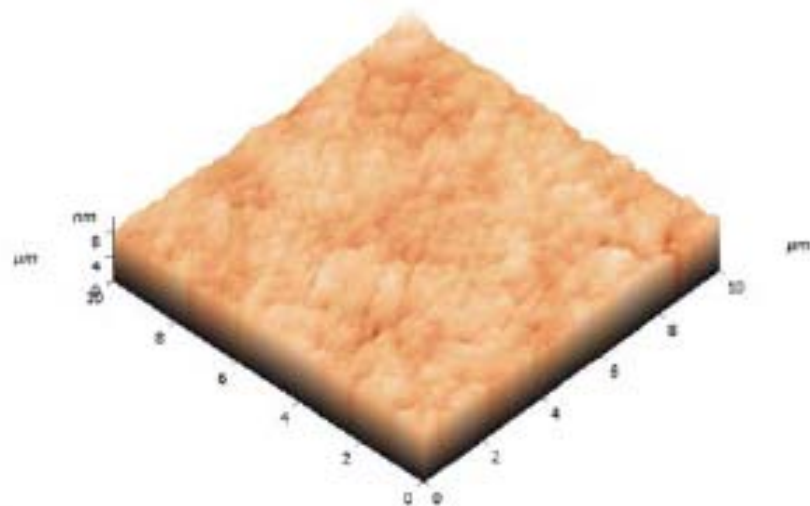




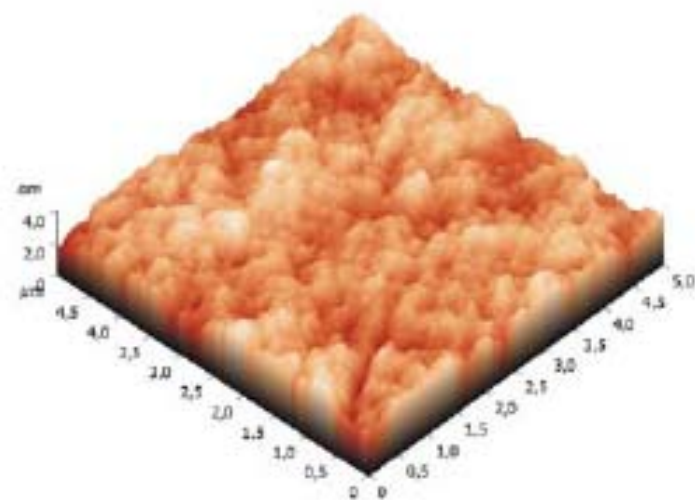
а



б



в



г

Рис. 4. 3D АСМ изображения поверхности образца №1 во второй точке.

## 900 mm long bars

### Surface roughness of specimen №1 in point 2

Scanned area, $\mu\text{m}$	Measured surface roughness, nm			
	$R_{\text{max}}$	$R_{\text{mean}}$	$R_a$	$R_q$
60×60 МКМ	109.435	8.820	0.492	0.839
30×30 МКМ	36.916	8.912	0.432	0.583
10×10 МКМ	10.544	8.240	0.361	0.469
5×5 МКМ	4.084	2.828	0.268	0.338

## 900 mm long bars

**Resulting surface roughness and finish (purity).**

<b>No</b>	<b>35×900 mm, nm</b>	<b>17×900 mm, nm</b>	<b>17×35 mm, nm</b>	<b>P</b>
<b>1</b>	<b>0.472- 0.749</b>	<b>0.790- 0.881</b>	<b>1.510- 0.631</b>	<b>V</b>
<b>2</b>	<b>0.472- 0.749</b>	<b>0.790- 0.881</b>	<b>1.510- 0.631</b>	<b>V</b>
<b>3</b>	<b>0.472- 0.749</b>	<b>0.790- 0.881</b>	<b>0.564- 0.604</b>	<b>V</b>
<b>4</b>	<b>0.472- 0.749</b>	<b>0.790- 0.881</b>	<b>0.564- 0.604</b>	<b>V</b>

**900 mm long bars**

**Squareness**

**Not measured, but attributed by producer as “ideal”. Should to be investigated.**

# **900 mm long bars**

## **Edges**

**Look sufficiently and sharp, but quite a few chips were damaged due to wrong manipulation when bars were taken off from the polishing table.**



## 900 mm long bars

### Surface and Edge Imperfections

**Bar №1: 2 chips 0.6×0.4×0.1 mm**

**Bar №2: 3 chips 1.8×1.0×0.1 mm; 1.4×0.9×0.4 mm;  
1.4×0.9×0.4 mm;**

**Bar №3: 4 chips 3.0×1.7×0.3 mm; 0.7×0.5×0.3 mm;  
3.6×1.8×0.2 mm; 0.5×0.4×0.1 mm**

**Bar №1: 1 chip 0.7×0.4×0.2 mm**

**The end**