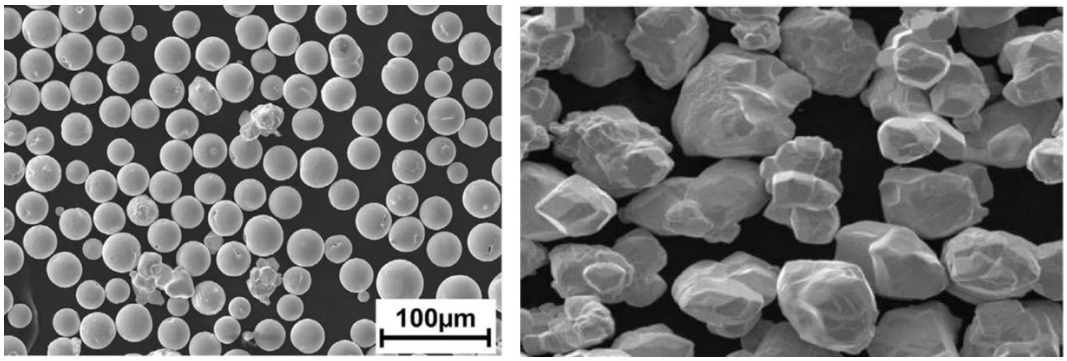
Work plan for SLM technologies

Summary:

Selective laser melting (SLM) is technology where 2D thin layers of atomized fine tungsten powder of the part geometry is fused byt selectively melting by a high-power laser beam. Tungsten SLM technology is owned by several companies, including: EOS, Plansee, Tekna, Farsoon Technologies, SIU System etc. NUST MISIS plans to develop tungsten printing technology to create a prototype calorimeter. For printing, tungsten powder of different quality is used (Fig. 1). Spherical powder allows to print the best quality details. The price of high quality powder is about 30 percent higher (EOS powder - 25 000 CHF per 100 Kg, Farsoon Technologies powder – about 18 000 CHF per 100 Kg).



a b

Fig. 1. Powder morphology: a - spherical powder manufactured by EOS (Germany), b - powder manufactured by Farsoon Technologies (China)

Main requirements for tungsten powder: granulometric composition 5-40 microns, d50=16 microns, chemical composition W min 99.95% (table 1). Quantity 100 kg.

Element	**Composition , %**	
	min	**max**
W	99,95	-
O	-	0,10
C	-	0,05
S	-	0,001
Al	-	0,001
Co	-	0,001
Cu	-	0,001
Mg	-	0,001
Mn	-	0,001
Pb	-	0,001

Cu	-	0,001
Ca	-	0,001
Cr	-	0,002
K	-	0,002
Na	-	0,002
Fe	-	0,002
Mo	-	0,003
Ni	-	0,003
Residual	-	0,025

Table 1. Chemical composition of the tungsten powder

Benefits of SLM:

1. No additional processing needed to make detail
2. Quick process of printing detail. For example, printing 23 prototypes requires 311 hours on FS271M machine (Fig. 2).

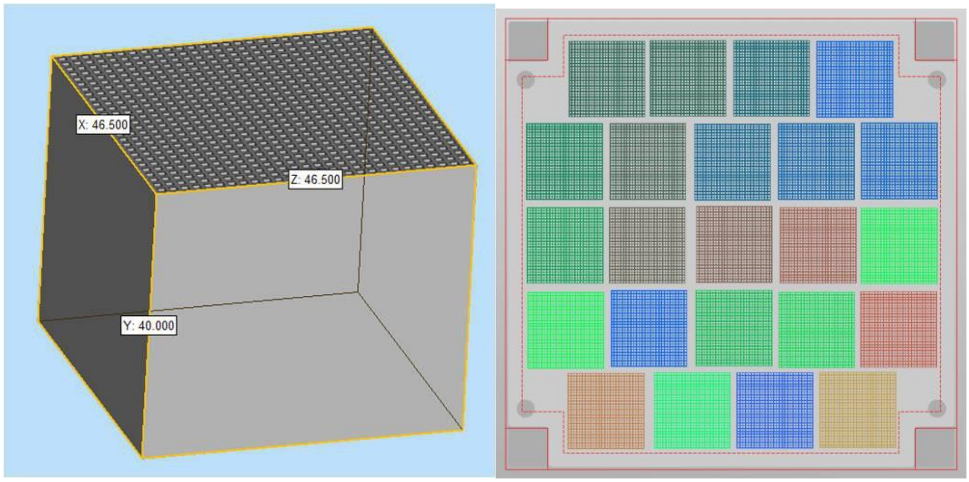


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Fig. 2. Image of detail (a) and arrangement of parts in the camera FS271M machine (b)

Challenges:

1. Cannot print tungsten alloys by SLM, because of the low vapor pressure of the additions for instance: W at 2350 K has 10^{-7} Pa, at 3000 K has 10^{-2}Pa; copper at 1600 K has 10^{5} Pa; iron and nickel at 2350 K has 10^{2} Pa. Hence, any elements except molybdenum during the synthesis using mixture with tungsten will burn out.
2. High roughness of detail obtained by the SLM method. (for prototype Ra = 5 μm (external); Ra = 9 μm (internal).
3. Density no more than 18 g/cm^3.

Plan:

The work is carried out in parallel to obtain three goals:

1. Goal: Check the roughness of the detail obtained from the tungsten powder by EOS

№	Stage name	Dates	Price	Goals	Responsible
1	Request a tungsten detail (Detail 1) obtained from EOS	24.02.2020 – 20.03.2020	-	Detail 1	Daria Strekalina
2	Measure the roughness of the detail 1	20.03.2020-27.03.2020	-	Roughness value	Daria Strekalina

2. Goal: Check the roughness of the detail obtained from the tungsten powder by Farsoon Technologies

№	Stage name	Dates	Price	Goals	Responsible
1	Design a drawing for detail about 2x4x4 cm (detail 2)	26.02.2020 – 28.03.2020	-	Detail drawing	Daria Strekalina (Ernest Sleptsov - graduate student)
2	Print detail 2 by Farsoon Technologies	1.04.2020-30.04.2020	Free	Detail 2	Nikita Voronov (Farsoon Technologies)
3	The effect of surface quality of detail 2 on GAGG crystals (measure roughness)	30.04.2020 – 06.05.2020	-	The effect of roughness on the surface of GAGG crystals	Daria Strekalina

3. Goal: Development of technology for producing an absorber by SLM

№	Stage name	Dates	Price	Goals	Responsible

1	Obtaining BAFA export permit for purchasing the tungsten powder from EOS	01.12.2019 – 31.03.2020	-	BAFA export permit	Daria Strekalina
2	Buying powder from EOS	31.03.2020-31.05.2020	25 000 CHF	Tungsten powder,100 kg	Daria Strekalina
3	Printing of the absorber prototype in NUST MISIS.	01.06.2020 – 30.07.2020	-	Development of the 3D printing technologies with W powder on equipment of NUST MISIS. Printing the prototype 46.5×46.5×100 mm^3.	Vladimir Korolev
4	Determination of roughness and tolerances during printing by EOS powder	30.07.2020 – 15.08.2020	-	Roughness and tolerances value	Daria Strekalina
5	Carrying out the beam tests on a prototype	October 2020	-	Investigation the influence of allowances level and the density of the absorber on its performance characteristics	
6	*Optimization of the print mode (if required)	01.09.2020 – 31.12.2020	20 000 - 25 000 CHF	Selection of parameters to improve technology	Vladimir Korolev

7	Reduce print costs	01.09.2020 – 31.12.2020	-	Search and selection of cheaper powder, investigate the influence of the quality of the powder on the quality of the final product.	Daria Strekalina, Vladimir Korolev

If goal 1 and 2 are not achieved (the roughness will be too high) then goal 3 will stop at the stage of buying powder from EOS (point № 2 in goal № 3).