**COMPARISON OF THE THERMAL AND MECHANICAL PROPERTIES OF TPG USED FOR SCT ATLAS MODULES**

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**Abstract**

We perform the measurements of thermal and mechanical properties of two types of TPG for using in the mechanical structure of the SCT modules for ATLAS .We compare the properties of the samples of TPG (Thermal Pyrolytic Graphite) manufactured by Advanced Ceramics[1] and ATOMGRAPH[2] .

# Introduction

To assist power dissipation in SCT ATLAS modules[1], in its mechanical framework (spine) high-thermal-conductive materials like TPG are used. This pure-carbon material is characterized by a high level of anisotropy in mechanical and thermal properties[2]. The parameters depend on many factors as the technology used by manufacturer, the value of the temperature of annealing and stress-annealing process, the thickness of the pre-produced sheets and etc. According to module design, the thickness of the TPG element of the spine is $500\mu m$ and three pads on it are profiled to a thickness of $250\mu m$. So, it is important to know the mechanical and thermal properties of the materiel used for serial production of the modules. Following this way, the thermal conductivity and mechanical property of two types of TPG materials, manufactured by Advanced Ceramics and ATOMGRAPH, are compared.

# The coefficient of the In-Plane Thermal Conductivity

The model of the measurements and the detail description of the setups used by us for measuring both values of the coefficient of the transverse (out-of-plane) and longitudinal (in-plane) thermal conductivity of the TPG samples is described in [3]. The results of the measurements of the coefficient of the in-plane thermal conductivity of TPG are shown in Fig.1. All our measurements were done inside a vacuum vessel at averaged temperature of the samples in region from $-5^0C$ up to $+35^0C$ at residual pressure near $10^{-2}mbar$. The measured values of the in-plane and transverse thermal conductivity for both materials are in agreement with independent measurements performed by another group using a different method[4].

# Transverse Pull Strength

A series of strength at tension tests was performed. The scheme of the measurement and the structure of the test samples is shown in Fig.2 . Two metal bars are glued together

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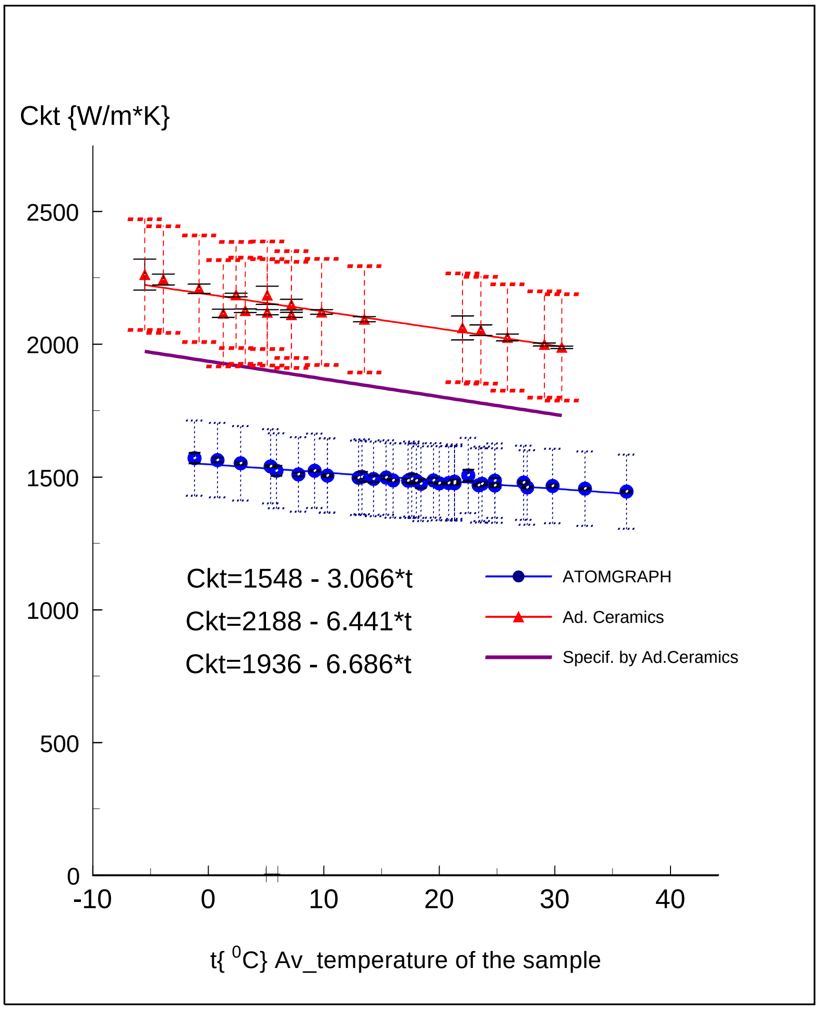


Figure 1: The value of $C_{kt}$- coefficient of the IN-PLANE Thermal conductivity. The solid line shows the coefficient $C_{kt}$ and its temperature dependence as advertised by Advanced Ceramics for its TPG material. The solid error bar line corresponds to the statistical errors, the dashed and dotted error bars include the systematic errors.

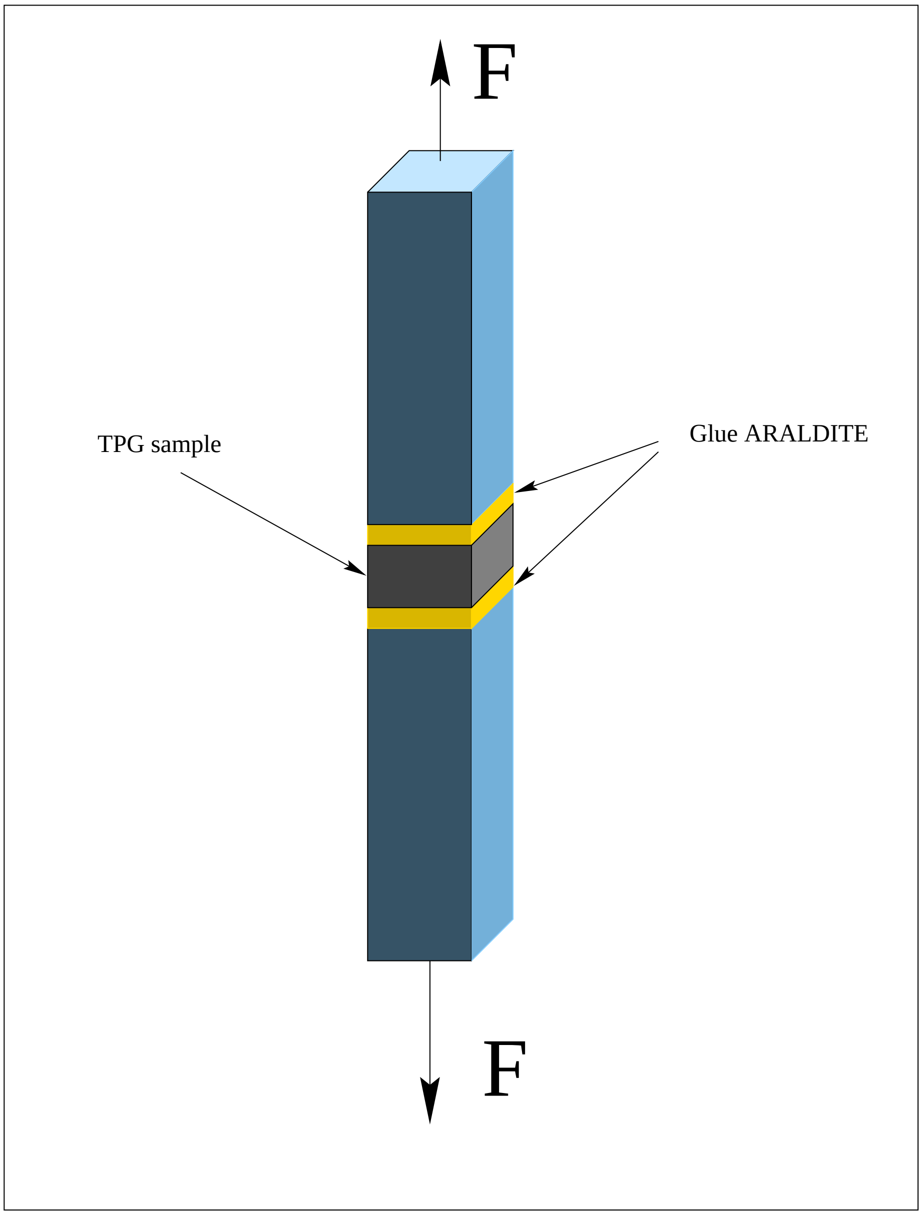


Figure 2: Schematic drawing of the measurement setup used for pull strength test.

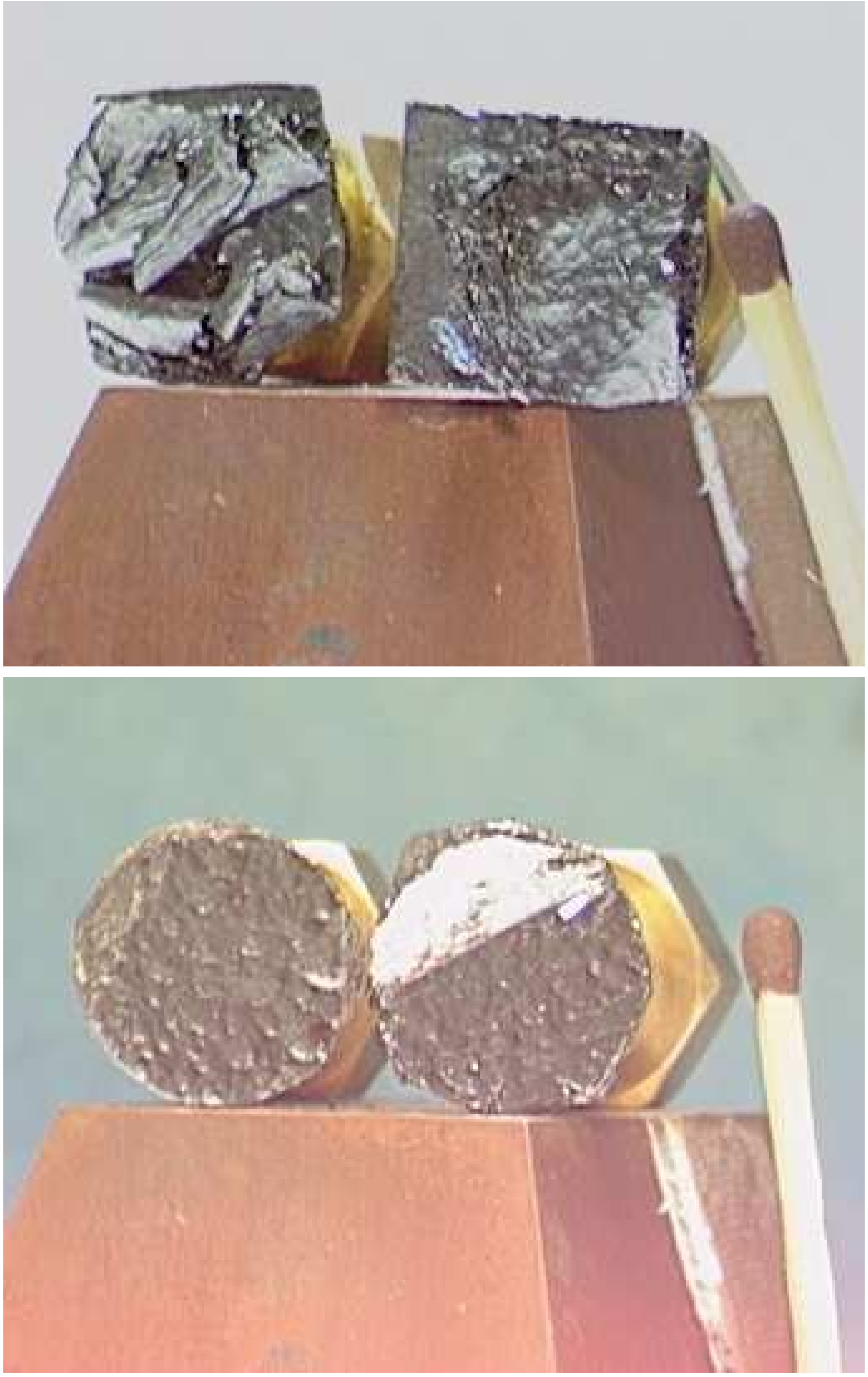

Figure 3: Typical view of disrupted samples (square and disc forms)

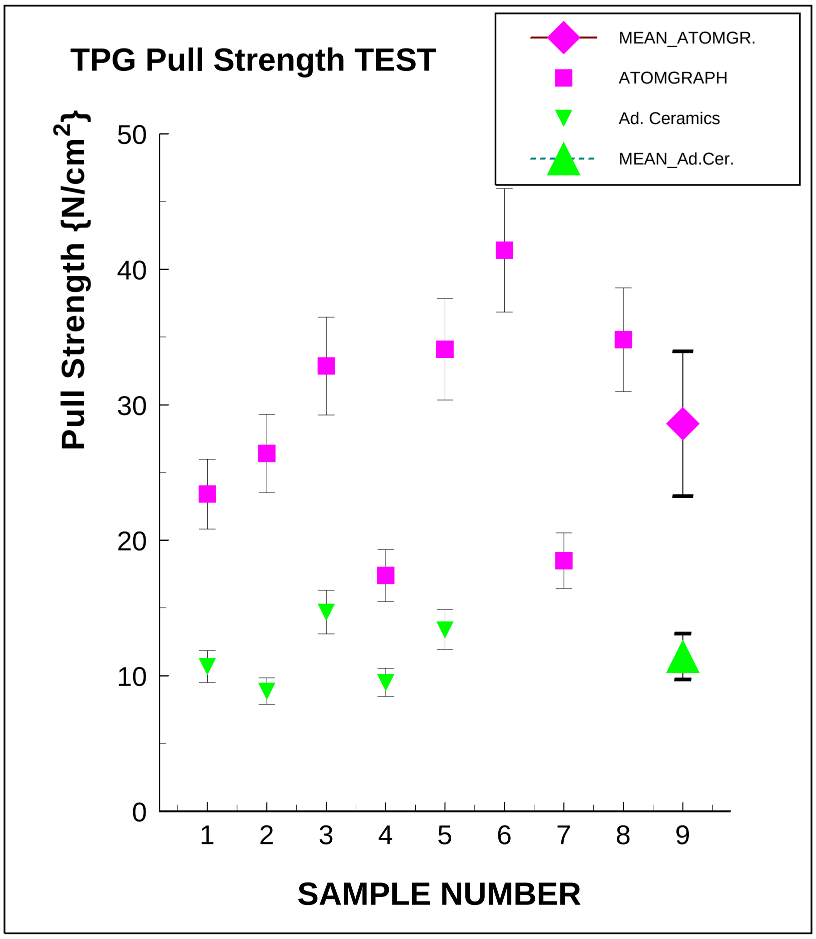


Figure 4: The value of PULL STRENGTH for the samples of Advanced Ceramics and ATOMGRAPH TPG .

through intermediate TPG insertion. The top side of upper bar is suspended to the support. A plastic vessel is clamped onto the bottom side of the lower bar. A slow going stream of water is flowing into the vessel up to the moment when the TPG insertion will disrupt. After destruction of the insertion the vessel was weighted. Typical views of disrupted samples are shown in Fig.3. Eight samples from ATOMGRAPH TPG and five from Advanced Ceramics were tested. The data of the pull strength are plotted in Fig.4. The large symbols in this plot corresponds to the average of all samples from each manufacturer.

# Conclusion

According to our measurements:

- The measured value the temperature dependence of $C_{kt}$ (slope) is :

  **Advan. Ceramics:** $-6.4\frac{W}{m\times{}^0C^2}$

  **ATOMGRAPH :** $-3.1\frac{W}{m\times{}^0C^2}$

- The measured value the temperature dependence of $C_{kt}$ for the Advanced Ceramics samples is close to dependence specified by this company for its material.

- The coefficient of the in-plane thermal conductivity of TPG (at $t = 20^0C$) is :

  - $\sim 2000^{\pm 200}\frac{W}{m\times K}$ for Advanced Ceramics ;
  - $\sim 1500^{\pm 120}\frac{W}{m\times K}$ for ATOMGRAPH ;

- The measured value of pull strength across layers of TPG is:

  - $\sim 11.4^{\pm 1.7}\frac{N}{cm^2}$ for Advanced Ceramics material;
  - $\sim 28.6^{\pm 5.3}\frac{N}{cm^2}$ for ATOMGRAPH samples;

# References


[1] T. Kondo et all ., ATLAS-INDET-98-201, 98-202

[2] A.V.Moore,"Highly Oriented Pyrolytic Graphite and its Intercalation Compounds", Chemistry and Physics of Carbon,1981,v.17,pp.233-304.

[3] C.Heusch, A.Kholodenko and H.-G.Moser, Direct Measurements of the Thermal Conductivity of Pyrolytic Graphite (PG) and Thermal Pyrolytic Graphite (TPG) samples for use as heat spreader material in ATLAS SCT MODULES, to be sub. to NIM.

[4] G.A.Beck et all ., ATLAS-INDET-98-221, 98-221