Measurement of elasticity & hysteresis of a kapton wire (3)

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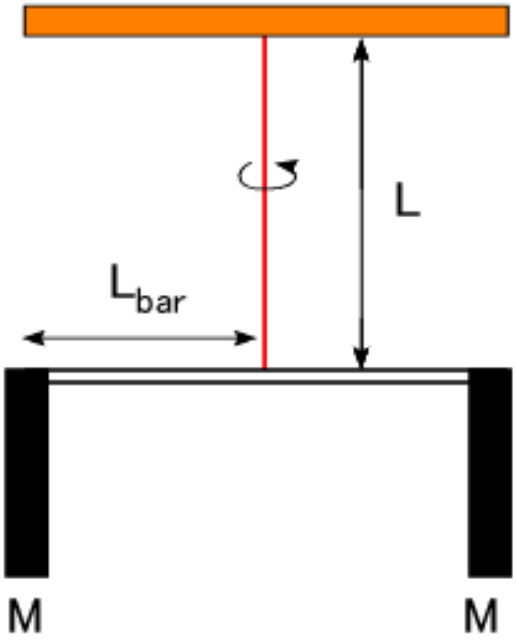
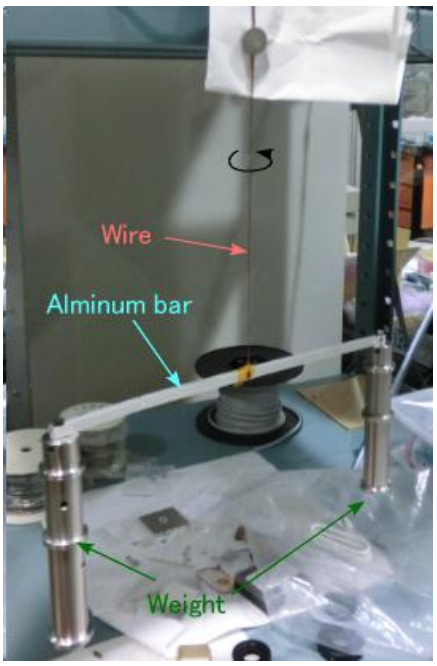
Experimental setup





* L_{bar}=17 cm
* The MOI of the aluminum bar: I_{bar}=1.7x10^{-4} kg m^2
* Measure the period of the torsion mode for various wire length (L) and weight (M)

Results (June 24, 2011)

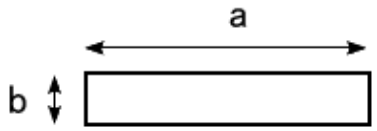
L [m]	M [kg]	I [kg m^2]	T [sec]
0.25	0.107	0.64 x 10^{-2}	20.0
	0.311	1.8 x 10^{-2}	34.0
	0.619	3.6 x 10^{-2}	49.0
0.50	0.107	0.64 x 10^{-2}	16.4
	0.311	1.8 x 10^{-2}	29.2
	0.619	3.6 x 10^{-2}	39.0
0.75	0.107	0.64 x 10^{-2}	11.6
	0.311	1.8 x 10^{-2}	20.0
	0.619	3.6 x 10^{-2}	27.8

Elastic constant & shear modulus

Elastic constant of the torsion mode is calculated as: $k_\theta = I(2\pi/T)^2$

Shear modulus estimation: $G = \frac{k_\theta L}{I_p}$,

The polar moment of area of the wire (I_P) with rectangular (a x b) cross section is: $I_p = \frac{ab^3}{3}(a >> b)$



In this case (a=2.30 mm, b=0.50 mm), I_p=9.6 x 10^{-14} kg m^2.

From the results of the experiment, the shear modulus is calculated as follows:

L [m]	I [kg m²]	T [sec]	k [Nm/rad]	G [GPa]
0.25	0.64 x 10^{-2}	20.0	0.63 x 10^{-3}	4.94
	1.8 x 10^{-2}	34.0	0.63 x 10^{-3}	4.90
	3.6 x 10^{-2}	49.0	0.60 x 10^{-3}	4.67
0.50	0.64 x 10^{-2}	16.4	0.94 x 10^{-3}	4.90
	1.8 x 10^{-2}	29.2	0.85 x 10^{-3}	4.43
	3.6 x 10^{-2}	39.0	0.94 x 10^{-3}	4.91
0.75	0.64 x 10^{-2}	11.6	1.9 x 10^{-3}	4.90
	1.8 x 10^{-2}	20.0	1.8 x 10^{-3}	4.72
	3.6 x 10^{-2}	27.8	1.9 x 10^{-3}	4.85

Shear modulus (G) is related to Young's modulus (E) by the following formula:

$$G = \frac{E}{2(1+\sigma)} \approx 4.8\,\text{GPa}$$

From the result of the previous experiment, we know:

$$\frac{E}{1-\sigma^2} \approx 24\,\text{GPa}$$

Then solving these equations for E and σ, we obtain

$$E = 15\,\text{GPa},\ \sigma = 0.6$$