ICICE 2023
International Conference on Innovation, Communication and Engineering
Bangkok, Thailand, 09-13 November 2023
INTERNATIONAL (TAIWANESE) INSTITUTE OF KNOWLEDGE INNOVATION
MNSA Micro NanoStructure Analysis Lab

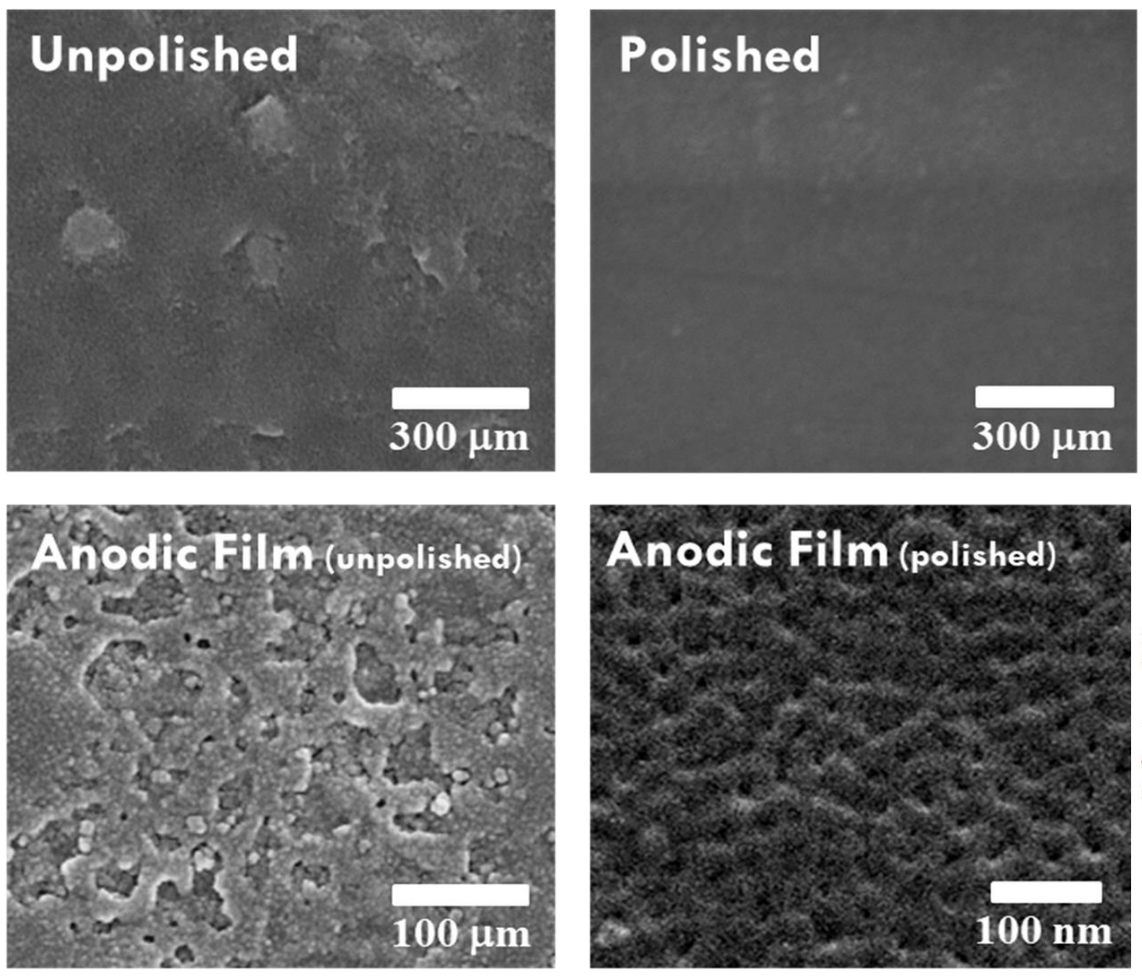
The Photothermal Characteristics of Porous Anodic Aluminum Oxide film

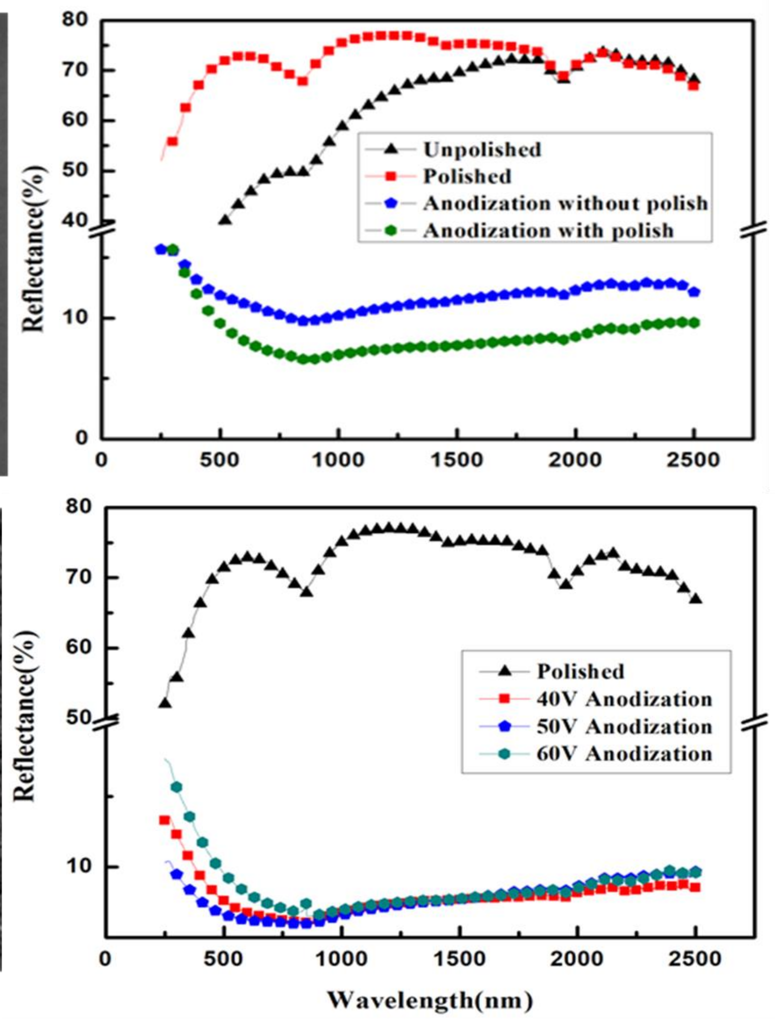
Tsung-Chieh Cheng[a, *], Te-Hua Fang[a], Ching-Yao Lin[b]

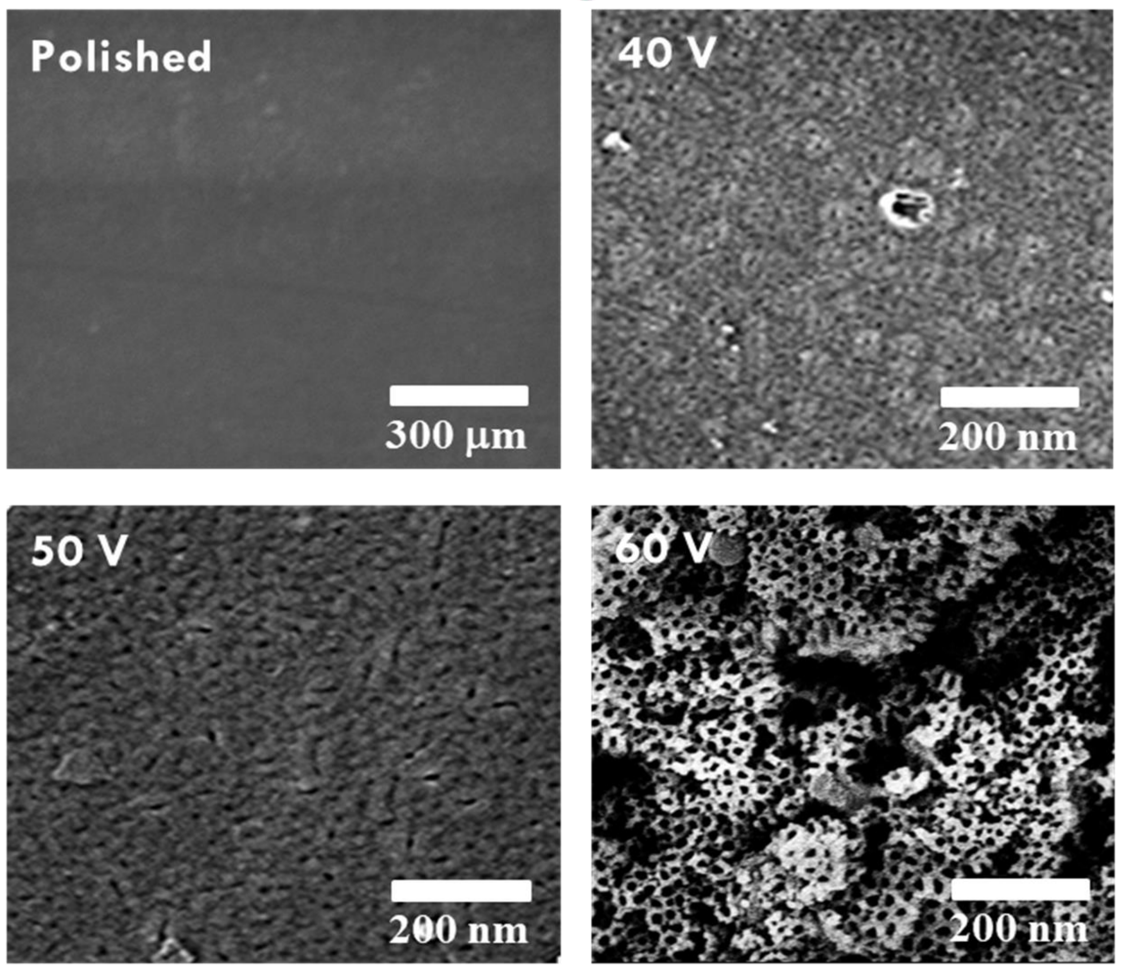
[a] Department of Mechanical Engineering, National Kaohsiung University of Sciences and Technology, No.415, Jiangong Rd., Sanmin Dist., Kaohsiung City 807, Taiwan, e-mail: tcchengme@nkust.edu.tw

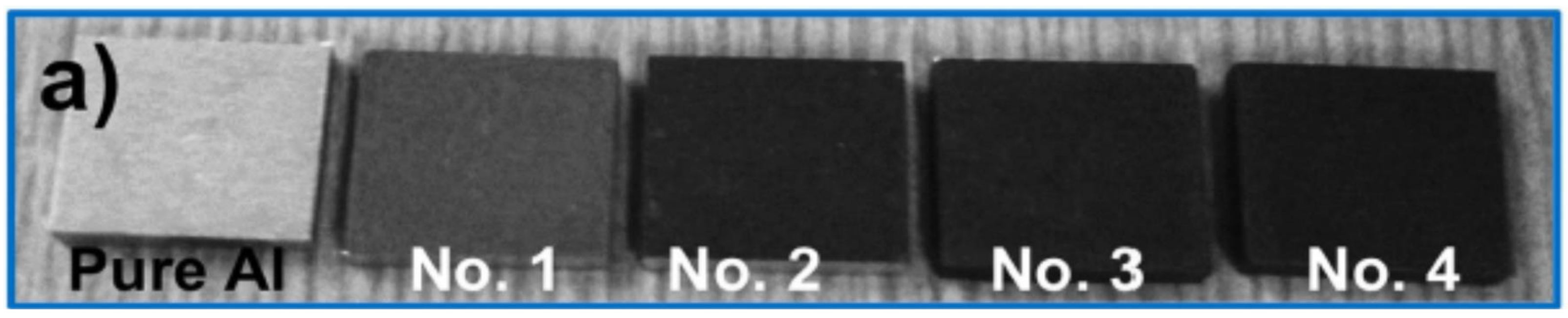
[b] Department of Digital Media Design, Tzuhui Institute of Technology, No.367, Sanmin Rd. Nanjhou Hsian, Pingtung, Taiwan

Reflectance of Films with Different Processes & Different Anodic Voltages

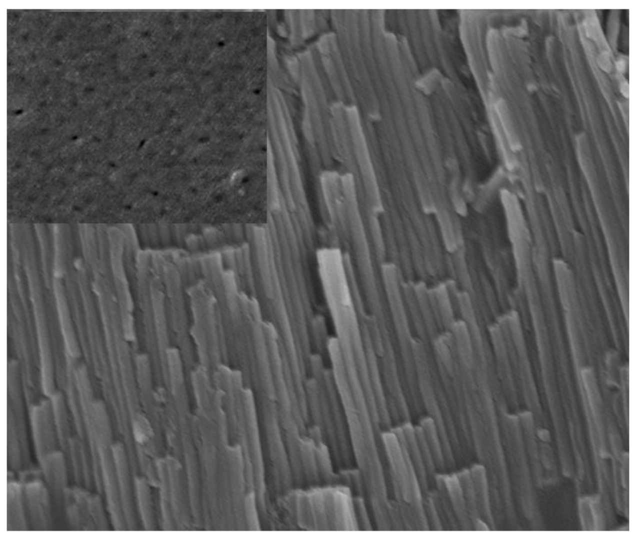


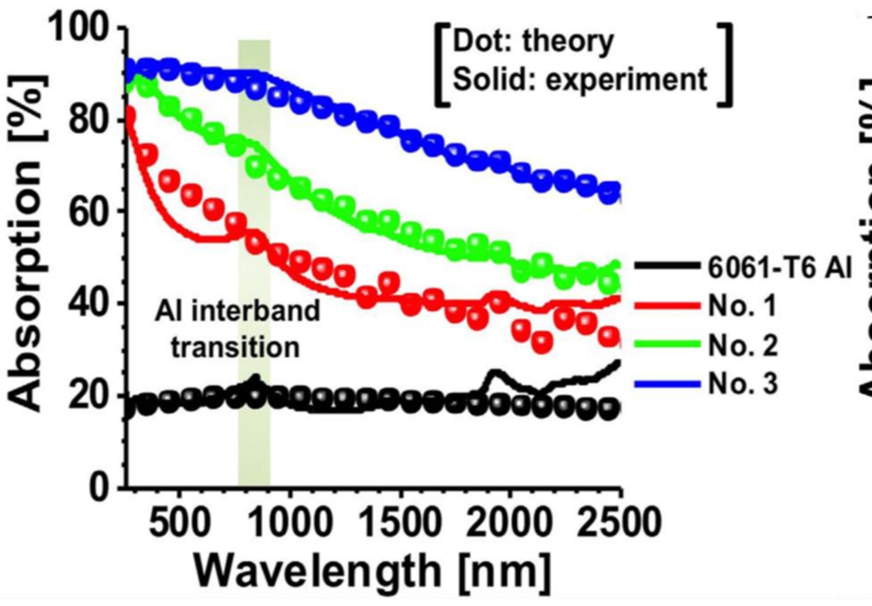


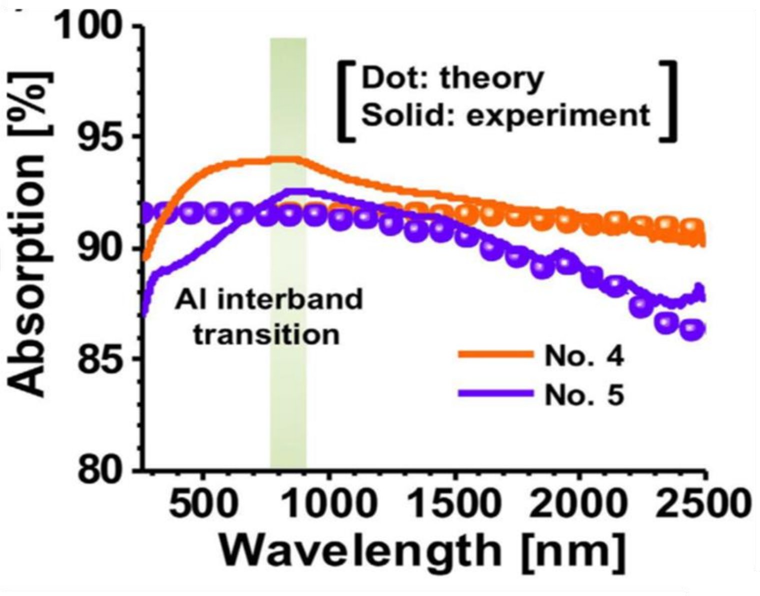




Sample No.	Process temperature [°C]	Process Voltage [V]	Air-filling ratio [%]	Thickness [μm]
1	0	30	7	3.8
2	5	30	10	7.8
3	10	30	13	19
4	10	50	21	103
5	10	40	19	58.5
6061-T6 Al	—	—	0	0







Maxwell-Garnett theory:

For an N-phase composite medium consisting of randomly distributed subwavelength inclusions, Macroscopic effective permittivity ε_{eff} can be analytically derived from the as:

$$\frac{\varepsilon_{\mathrm{eff}}-\varepsilon_{\mathrm{m}}}{\varepsilon_{\mathrm{eff}}+2\varepsilon_{\mathrm{m}}}=\sum_{n=1}^{N}p_{\mathrm{n}}\frac{\varepsilon_{i,n}-\varepsilon_{\mathrm{m}}}{\varepsilon_{i,n}+2\varepsilon_{\mathrm{m}}}.$$

where

p_n and $\varepsilon_{i,n}$ are the volume fraction and relative permittivity of the N-th inclusion in this mixture

ε_m is the relative permittivity of host matrix (nanopores filled with air, i.e. $\varepsilon_m = 1$)

The effective relative permittivity is given by:

$$\frac{\varepsilon_{\mathrm{eff}}}{\varepsilon_{\mathrm{MMO}}}=\frac{2\varepsilon_{\mathrm{MMO}}(1-\delta)+(1+2\delta)}{1-\delta+\varepsilon_{\mathrm{MMO}}(2+\delta)}$$

ε_{MMO} is metal oxide host matrix of relative permittivity
δ is the volume fraction of air nanopores

Use transmission line (TL) approach

the reflection coefficient at the input of MMO surface can be derived as

$$\Gamma^{\mathrm{TE,TM}}(\theta)=\frac{Z_{\mathrm{MMO}}^{\mathrm{TE,TM}}(Z_{\mathrm{M}}^{\mathrm{TE,TM}}-Z_{0}^{\mathrm{TE,TM}})-i[(Z_{\mathrm{MMO}}^{\mathrm{TE,TM}})^{2}-Z_{\mathrm{M}}^{\mathrm{TE,TM}}Z_{0}^{\mathrm{TE,TM}}]\tan(\beta_{\mathrm{MMO}}^{\mathrm{TE,TM}}l)}{Z_{\mathrm{MMO}}^{\mathrm{TE,TM}}(Z_{\mathrm{M}}^{\mathrm{TE,TM}}+Z_{0}^{\mathrm{TE,TM}})+i[(Z_{\mathrm{MMO}}^{\mathrm{TE,TM}})^{2}+Z_{\mathrm{M}}^{\mathrm{TE,TM}}Z_{0}^{\mathrm{TE,TM}}]\tan(\beta_{\mathrm{MMO}}^{\mathrm{TE,TM}}l)}$$

where $Z_i^{TM} = \eta_i \cos \theta_i$, $Z_i^{\mathrm{TE}} = \eta_i / \cos \theta_i$ of the i-th medium for TM and TE incident waves

and $\theta_i = \sin^{-1}(\sqrt{k_i^2 - \beta_0^2})$, $k_i = \omega\sqrt{\varepsilon_0\varepsilon_i\mu_0}$, $\eta_i = \sqrt{\mu_0/(\varepsilon_0\varepsilon_i)}$

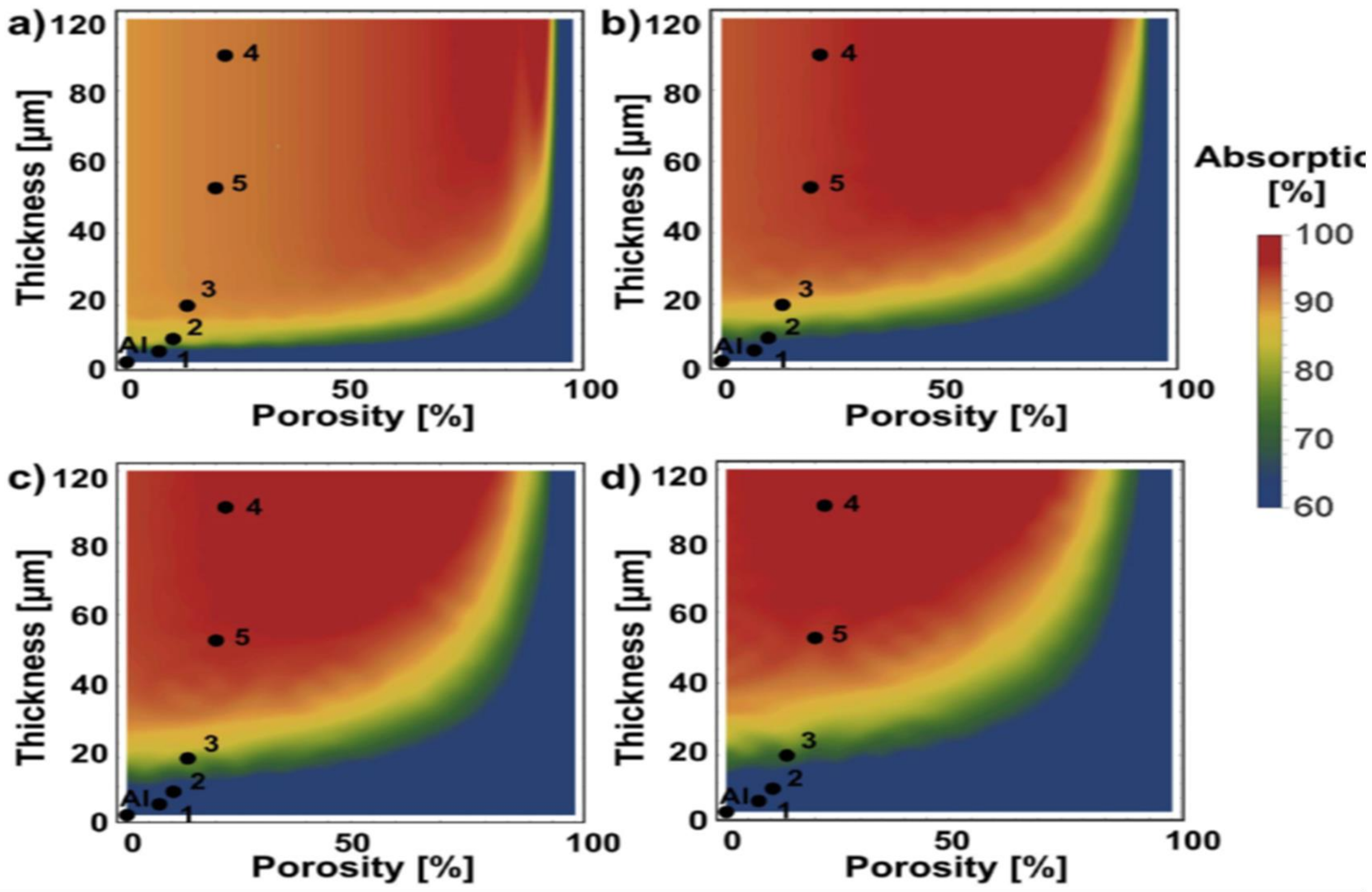
Total absorption of this system is given by

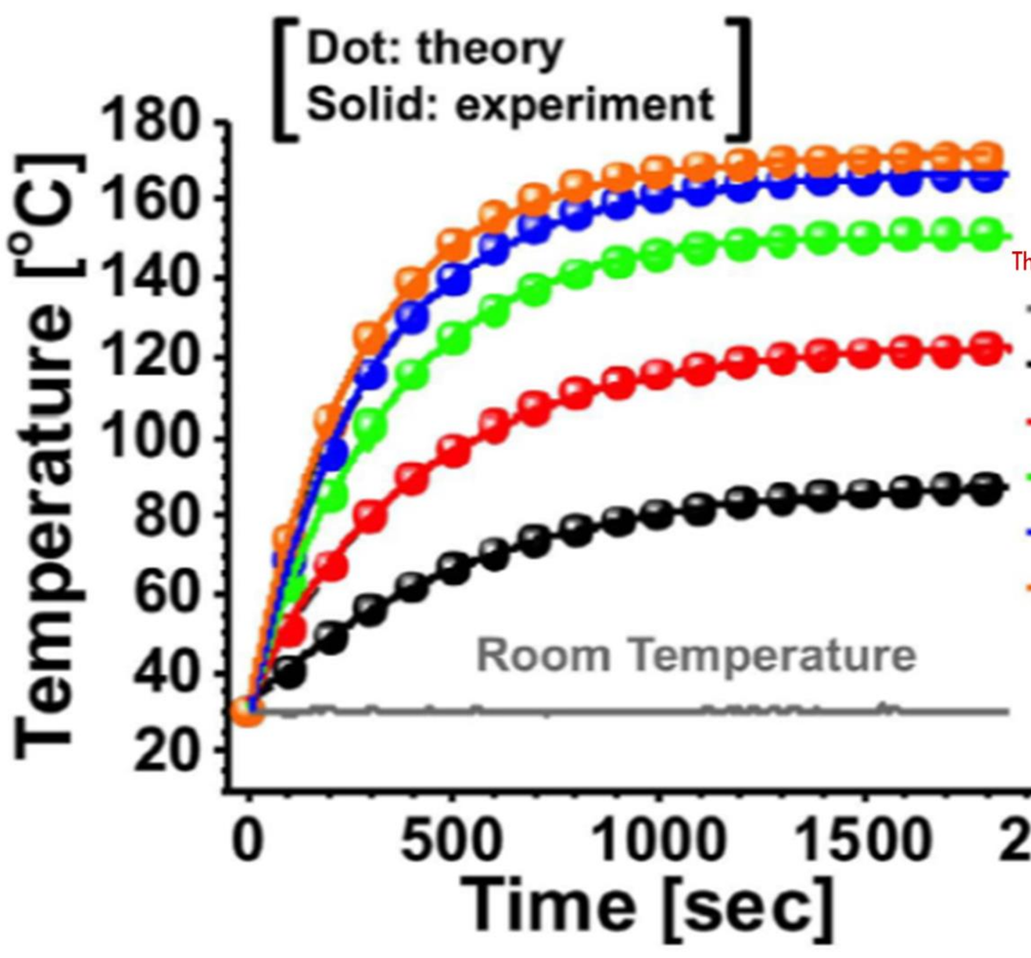
$$A^{\mathrm{TE,TM}}(\theta) = 1 - |\Gamma^{\mathrm{TE,TM}}(\theta)|^2$$

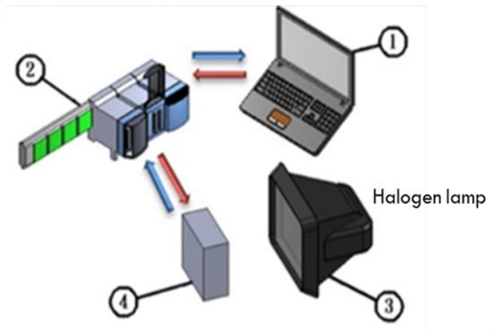
The measured average absorption over all angle

$$A_{sph} = \int_0^{\pi/2} \frac{A^{TM}(\theta) + A^{TE}(\theta)}{2} d\theta \Big/ \int_0^{\pi/2} d\theta$$

The refractive index of the MMO layer (AAO here) is $n_{MMO} = n_{AAO} = \sqrt{\varepsilon_{AAO}} = 1.5 + 0.005i$ valid at wavelengths of interest. We note that the imaginary part of n_{AAO} is significantly larger than that of most AAO membranes and is expected to enhance the absorption of incident radiation.







The intensity of impinging light is $P_{inc} = 5W/cm^2$