풀이 (실험 문제):

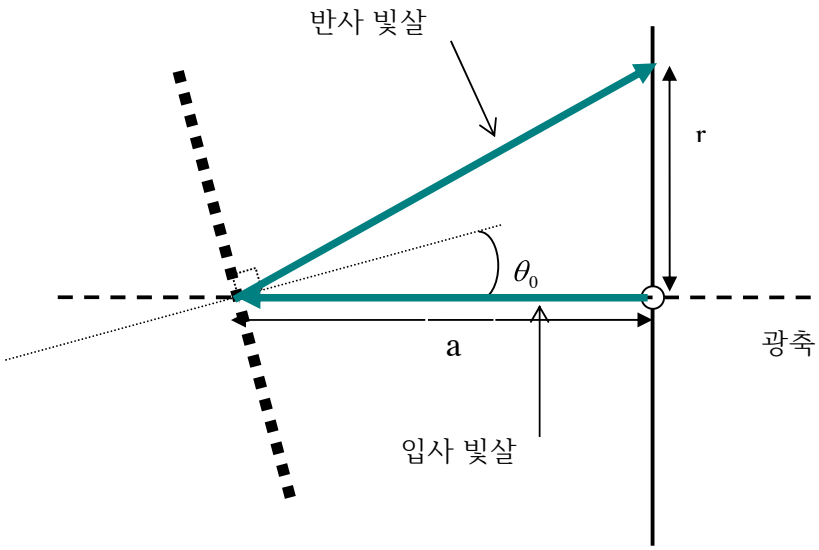
과제 1

1a.

$\Delta\theta_{\Delta\theta\text{공칭}}$:5′=0.08°

$\Delta\theta_{\Delta\theta\text{공칭 (도)}}$	0.08

1b.



a가 카드와 회절격자 사이의 거리이고 r" 가 구멍과 빛점 사이의 거리이면 다음을 얻는다

$$\Delta f(x_1, x_2, ...) = \sqrt{\left(\frac{\partial f}{\partial x_1}\Delta x_1\right)^2 + \left(\frac{\partial f}{\partial x_2}\Delta x_2\right)^2 + ...}$$

$$\tan(2\theta_0) = \frac{r}{a},\ If\ \theta_0 << 1 \Rightarrow \theta_0 = \frac{r}{2a} \Rightarrow \Delta\theta_0 = \sqrt{\left(\frac{\Delta r}{2a}\right)^2 + \left(\frac{r\,\Delta a}{2a^2}\right)^2}$$

θ_0이 0이기를 바라므로, 곧 $r = 0 \Rightarrow \Delta\theta_0 = \frac{\Delta r}{2a}$

$$\Delta r = 1mm,\ a = (70 \pm 1)mm \Rightarrow \theta_0 = \frac{\Delta r}{2a}\ rad = 0.007\ rad = 0.4^\circ$$

$\Delta\theta_0$	0.4°
θ가시광선의 범위 (도)	13°≤ θ ≤26°

1c.

$R_{\min}^{(0)}$	(21.6±0.1) kΩ
$\Delta\varphi_0$	5′ = 0.08°
$R_{\min}^{(1)}$	R=(192±1) kΩ

$\Delta\varphi_{\Delta\theta_0=5'}$ 그 까닭은

θ = 5′ => R= (21.9±0.1) kΩ

θ =-5′ => R= (21.9±0.1) kΩ

1d.

표 1d. 잰 매개변수

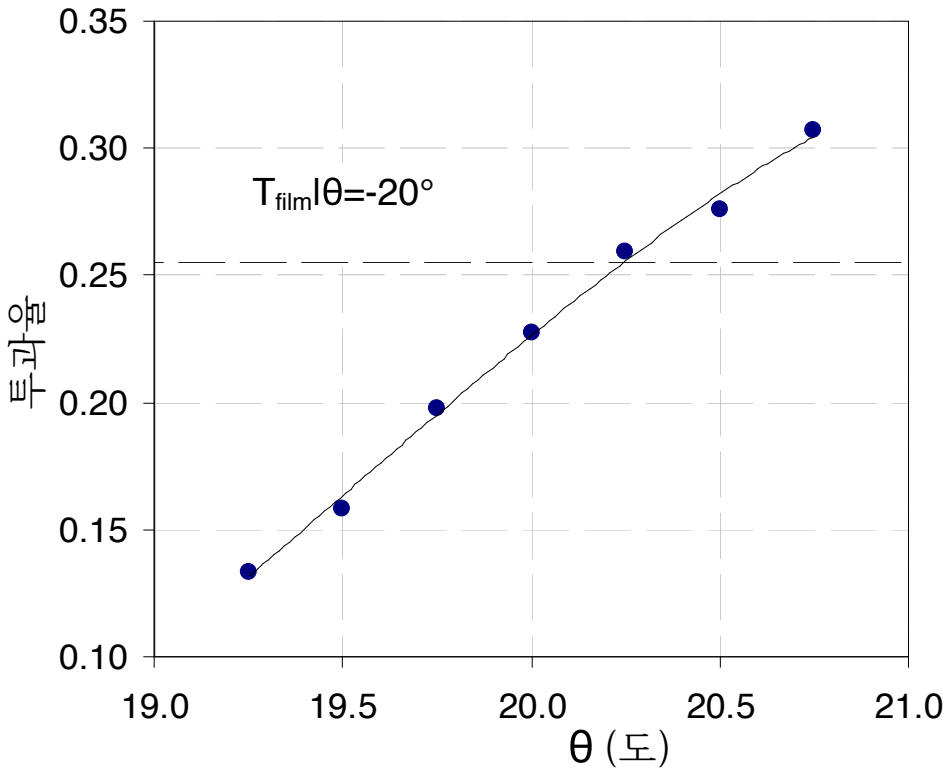
θ (도)	R_{glass}(MΩ)	ΔR_{glass}(MΩ)	R_{film}(MΩ)	ΔR_{film}(MΩ)
15.00	3.77	0.03	183	3
15.50	2.58	0.02	132	2
16.00	1.88	0.01	87	1
16.50	1.19	0.01	51.5	0.5
17.00	0.89	0.01	33.4	0.3
17.50	0.68	0.01	19.4	0.1
18.00	0.486	0.005	10.4	0.1
18.50	0.365	0.005	5.40	0.03
19.00	0.274	0.003	2.66	0.02
19.50	0.225	0.002	1.42	0.01
20.00	0.200	0.002	0.880	0.005
20.50	0.227	0.002	0.822	0.005
21.00	0.368	0.003	1.123	0.007
21.50	0.600	0.005	1.61	0.01
22.00	0.775	0.005	1.85	0.01
22.50	0.83	0.01	1.87	0.01
23.00	0.88	0.01	1.93	0.02
23.50	1.01	0.01	2.14	0.02
24.00	1.21	0.01	2.58	0.02
24.50	1.54	0.01	3.27	0.02
25.00	1.91	0.01	4.13	0.02
16.25	1.38	0.01	66.5	0.5
16.75	1.00	0.01	40.0	0.3
17.25	0.72	0.01	23.4	0.2
17.75	0.535	0.005	12.8	0.1
18.25	0.391	0.003	6.83	0.05
18.75	0.293	0.003	3.46	0.02
19.25	0.235	0.003	1.76	0.01
19.75	0.195	0.002	0.988	0.005
20.25	0.201	0.002	0.776	0.005
20.75	0.273	0.003	0.89	0.01

1e.

θ=－20°에서 ⇒ R_{glass}= (132± 2) kΩ , R_{film}= (518±5) kΩ

θ	T_{film}	θ	T_{film}
θ = -20°	0.255	19.25	0.134
		19.50	0.158
		19.75	0.197
		20.00	0.227
		20.25	0.259
		20.50	0.276
		20.75	0.307

그래프



다음을 알 수 있다: T(θ= 20.25°) = T(θ= -20°)

δ (도)	0.25±0.08

과제 2.

2a.

$$\lambda = d\sin\left(\theta - \frac{\delta}{2}\right) \Rightarrow \Delta\lambda = \lambda\sqrt{\left(\frac{\Delta d}{d}\right)^2 + \cot^2\left(\theta - \frac{\delta}{2}\right)\left(\Delta\theta^2 + \frac{\Delta\delta^2}{4}\right)} \approx d\ \cos(\theta)\left(\frac{0.1\pi}{180}\right)$$

여기서 $\Delta\theta = \Delta\delta = 5' = 0.08$ 도

그리고 $d = \frac{1}{600}$ mm

$$\boxed{\Delta\lambda = 2.9\cos(\theta)\ (\text{nm})}$$

$$T_{film} = \frac{R_{glass}}{R_{film}} \Rightarrow \Delta T = T_{film}\sqrt{\left(\frac{\Delta R_{film}}{R_{film}}\right)^2 + \left(\frac{\Delta R_{glass}}{R_{glass}}\right)^2}$$

$$\boxed{\Delta T = \frac{R_{glass}}{R_{film}}\sqrt{\left(\frac{\Delta R_{film}}{R_{film}}\right)^2 + \left(\frac{\Delta R_{glass}}{R_{glass}}\right)^2}}$$

2b.

$$13 \le \theta \le 26$$

$$\boxed{2.6 \le \Delta\lambda \le 2.8\ \text{nm}}$$

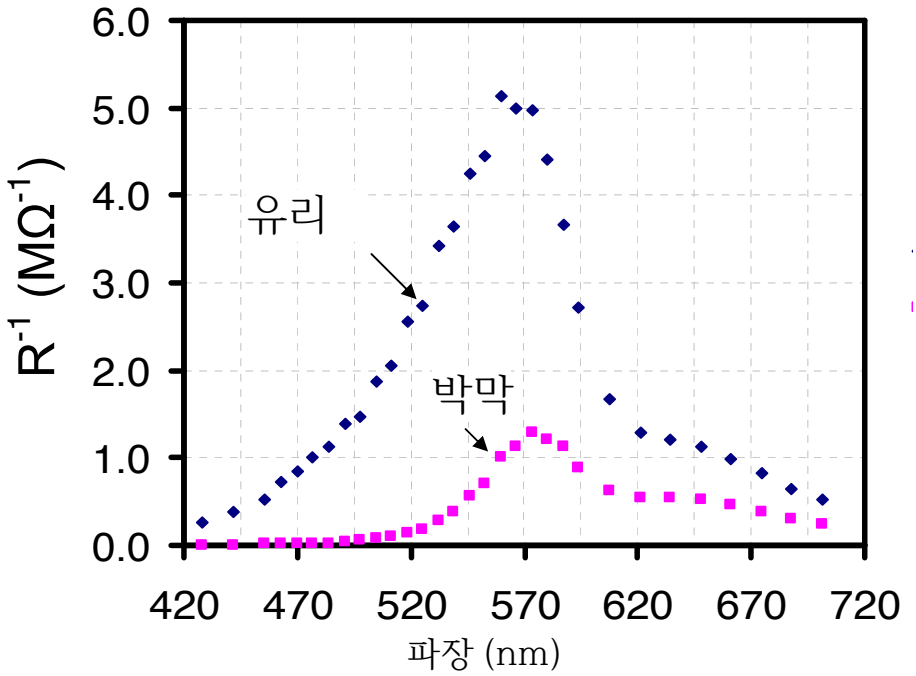
2c.

표 2c. 잰 매개변수로 계산한 값

θ (도)	λ (nm)	$I_g/C(\lambda)$ ($M\Omega^{-1}$)	$I_s/C(\lambda)$ ($M\Omega^{-1}$)	T_{film}	αt
15.0	428	0.265	0.00546	0.0206	3.88
15.5	442	0.388	0.00758	0.0195	3.94
16.0	456	0.532	0.0115	0.0216	3.83
16.25	463	0.725	0.0150	0.0208	3.88
16.5	470	0.840	0.0194	0.0231	3.77
16.75	477	1.00	0.0250	0.0250	3.69
17.0	484	1.12	0.0299	0.0266	3.63
17.25	491	1.39	0.0427	0.0308	3.48
17.5	498	1.47	0.0515	0.0351	3.35
17.75	505	1.87	0.0781	0.0418	3.17
18.0	512	2.06	0.096	0.0467	3.06
18.25	518	2.56	0.146	0.0572	2.86
18.5	525	2.74	0.185	0.0676	2.69
18.75	532	3.41	0.289	0.0847	2.47
19.0	539	3.65	0.376	0.103	2.27
19.25	546	4.26	0.568	0.134	2.01
19.5	553	4.44	0.704	0.158	1.84
19.75	560	5.13	1.01	0.197	1.62
20.0	567	5.00	1.14	0.227	1.48
20.25	573	4.98	1.29	0.259	1.35
20.5	580	4.41	1.22	0.276	1.29
20.75	587	3.66	1.12	0.307	1.18
21.0	594	2.72	0.890	0.328	1.12
21.5	607	1.67	0.621	0.373	0.99
22.0	621	1.29	0.541	0.419	0.87
22.5	634	1.20	0.535	0.444	0.81
23.0	648	1.14	0.518	0.456	0.79
23.5	661	0.99	0.467	0.472	0.75
24.0	675	0.826	0.388	0.469	0.76
24.5	688	0.649	0.306	0.471	0.75
25.0	701	0.524	0.242	0.462	0.77

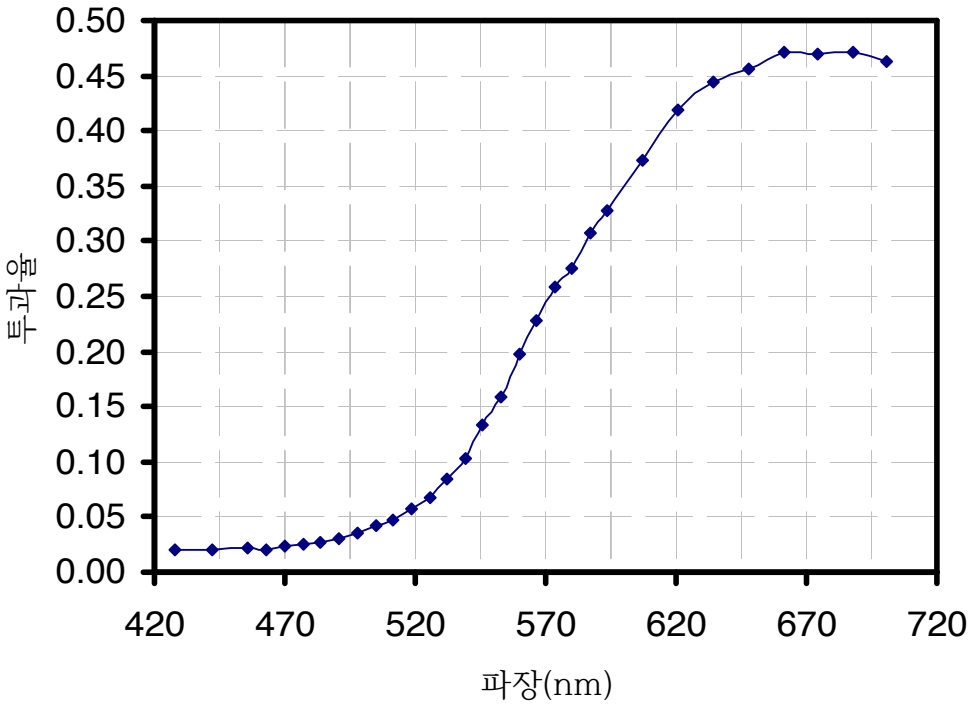
2d.

그래프



$\lambda_{max}(I_{glass})$	564±5 (nm)
$\lambda_{max}(I_{film})$	573±5 (nm)

2e. 그래프



과제 3.

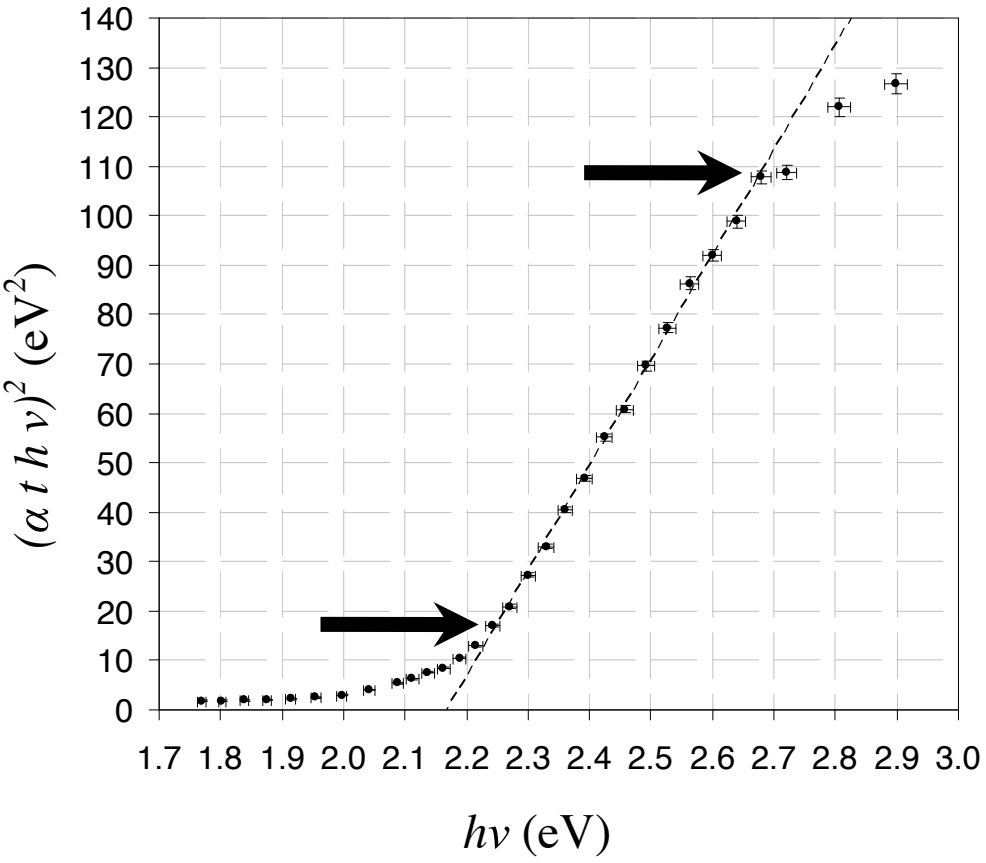
3a.

표 3a. 각 측정 데이터 점에 대해 계산한 값

θ (도)	x (eV)	y (eV^2)
15.00	2.898	126.6
15.50	2.806	121.9
16.00	2.720	108.8
16.25	2.679	107.8
16.50	2.639	98.9
16.75	2.600	92.0
17.00	2.563	86.3
17.25	2.527	77.4
17.50	2.491	69.7
17.75	2.457	60.9
18.00	2.424	55.1
18.25	2.392	46.8
18.50	2.360	40.4
18.75	2.330	33.1
19.00	2.300	27.3
19.25	2.271	20.91
19.50	2.243	17.07
19.75	2.215	12.92
20.00	2.188	10.51
20.25	2.162	8.53
20.50	2.137	7.56
20.75	2.112	6.23
21.00	2.088	5.43
21.50	2.041	4.06
22.00	1.997	3.02
22.50	1.954	2.52
23.00	1.914	2.26
23.50	1.875	1.98
24.00	1.838	1.94
24.50	1.803	1.84
25.00	1.769	1.86

3b.

그래프



$x_{min} = 2.24(\text{eV})$	$x_{max} = 2.68(\text{eV})$

3c.

$$\alpha h\nu = A\left(h\nu - E_g\right)^{\frac{1}{2}} \Rightarrow (\alpha t\, h\nu)^2 = (At)^2\left(h\nu - E_g\right)$$

$$\Rightarrow y = (At)^2\left(x - E_g\right) \Rightarrow m = (At)^2 \Rightarrow t = \frac{\sqrt{m}}{A}$$

$$\Rightarrow \frac{\Delta t}{t} = \frac{\Delta m}{2m}$$

$t = \frac{\sqrt{m}}{A}$
$\Delta t = \frac{\Delta m}{2A\sqrt{m}}$

선형 영역에서 m=213 (eV), r^2= 0.9986, E_g=2.17 (eV)를 얻고
또한 $A = 0.071\ (\mathrm{eV}^{1/2}/\mathrm{nm})$이므로 t= 206 (nm)를 얻는다

$$\Delta m = \sqrt{\frac{(\delta y)^2 + \frac{m^2}{R^2}(\delta x)^2}{\sum_i x_i^2 - N\bar{x}^2}} \approx \sqrt{\frac{(\delta y)^2 + (m\,\delta x)^2}{\sum_i x_i^2 - N\bar{x}^2}} = \sqrt{\frac{(\delta xy)^2}{\sum_i x_i^2 - N\bar{x}^2}},\ (\delta xy)^2 = (\delta y)^2 + (m\,\delta x)^2$$

여기서 Δx와 Δy는 x와 y 오차 범위의 평균이다

$$\delta x \approx \sqrt{\frac{\sum_i \delta x_i^{\,2}}{N}}\ \&\ \delta y = \sqrt{\frac{\sum_i \delta y_i^{\,2}}{N}}\ \ \text{So} \qquad \delta x \approx 0.014\ (\mathrm{eV}),\ \delta y \approx 0.9\,(\mathrm{eV})^2$$

→ $\Delta m \approx 10$ (eV) → $\Delta t = t \times \Delta m/(2\ m) \approx 5$ (nm)

$$\Delta E_g = \frac{1}{m}\sqrt{\left(\left(\frac{m^2\,\delta x^2 + \delta y^2}{N}\right) + \left(\frac{\bar{y}}{m}\right)^2 \Delta m^2\right)} = \frac{1}{m}\sqrt{\left(\left(\frac{\delta xy^{\,2}}{N}\right) + \left(\frac{\bar{y}}{m}\right)^2 \Delta m^2\right)}$$

$$\Delta E_g \approx 0.02(\mathrm{eV})$$

표 3d. 그림 3으로 계산한 E_g와 t의 값

E_g (eV)	ΔE_g (eV)	t (nm)	Δt (nm)
2.17	0.02	206	5

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