1. Operational Procedures

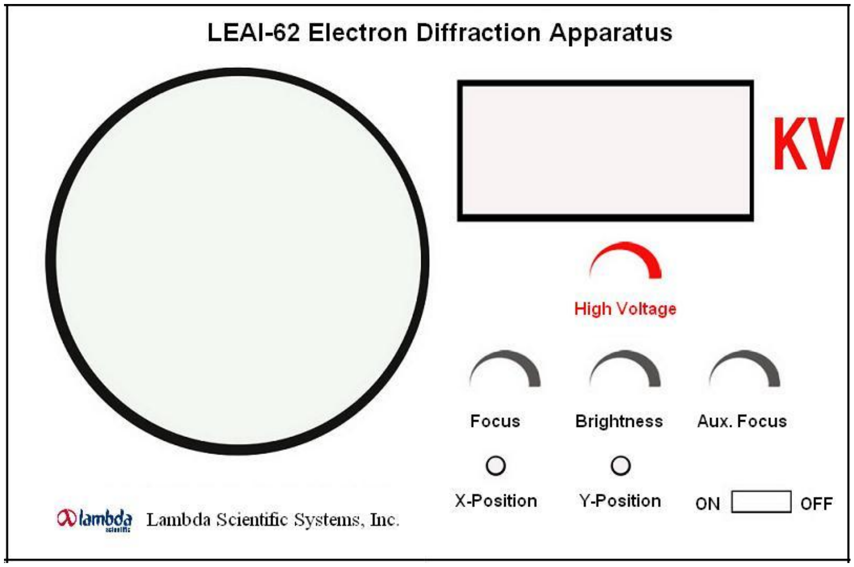

Figure 1 Schematic of front panel

1) Prior to turning on power, turn the high voltage multi-turn knob counter-clockwise to minimum, to prevent possible tube damage if high voltage is applied before warm-up.

2) Turn on power and preheat for 10 minutes or longer if necessary.

3) Set high voltage to round 6.0 kV, slowly adjust brightness, focus and auxiliary focus, until a light spot is observed on the screen. (If still no light spot is observed, try to adjust X-position and Y-position knobs concurrently.) **Note**: the X- and Y-position controls do not correspond to conventional X and Y axes, as these controls are not independent of each other but are correlated, so they should be used in a combined manner to steer the electron diffraction pattern to a proper location on the screen.

4) Adjust X-position and Y-position knobs to bring the pattern to a proper location on the screen to achieve the best effect (the best focusing location may not be at the center of the viewing screen). To extend the lifetime of the diffraction tube, it is preferred to set brightness at a moderate level. **Note**: do not remain the bright spot at a fixed location on the screen for a long time. When not observing pattern, turn high voltage to zero to preserve the lifetime of the electron tube.

5) Before doing measurement, wait a few minutes to allow the system to be warmed and stabilized. During experiment, increase high voltage slowly. After experiment, turn high

voltage knob to minimum location.

6) Turn off power.

2. Experimental Contents

A. <u>Measure electron wavelength and verify de Broglie relation</u>

Use the provided ruler to measure the radii of the diffraction rings on the screen at different accelerating voltages. Distance *D* from the target to the screen is given (on the back panel of the apparatus). Accelerating voltage can be read from the meter. Starting from 12 kV or higher (**note**: this start voltage may vary from batch to batch of the CRT), increase the accelerating voltage at a step of 1 kV while measuring the ring radius *r* of the same order at each accelerating voltage. Substitute *r* and *D* into Equations (3) and (8), respectively, calculate de Broglie wavelength, and compare the two results (since the target in this apparatus is gold, its lattice constant is a=0.40786 nm).

B. <u>Measure crystal lattice constant</u>

Measure the diffraction ring radii of planes (1 1 1), (2 0 0), (2 2 0), (3 1 1), (4 2 2), …, respectively, at different accelerating voltages (14 kV, 16 kV, 18 kV, and 20 kV), as shown in Figure 2. Use Equations (3) and (8) to calculate the lattice constant of gold.

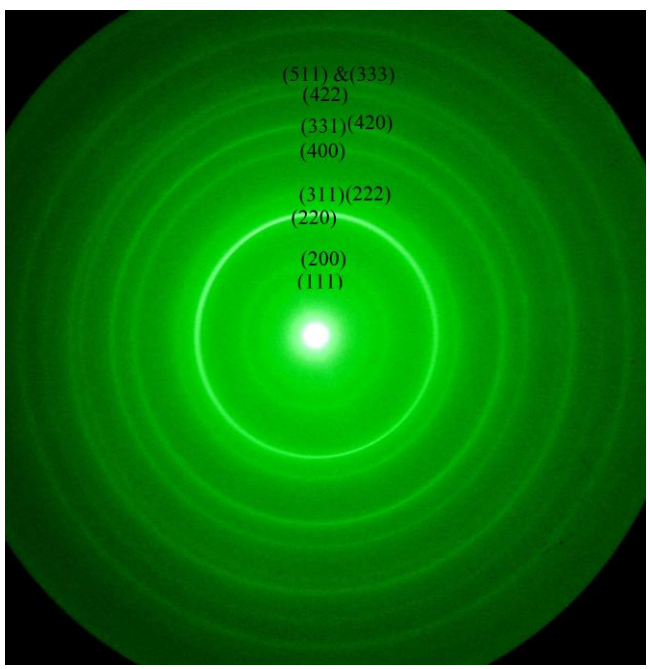

Figure 2 Assignment of electron diffraction rings

C. <u>Measure Miller indices</u>

Based on experiments A and B, design your own experiment to measure the Miller indices of the corresponding diffraction rings.

D. <u>Calculate Planck's constant</u>

According to experiment A, draw graph of $\lambda^2 \sim \frac{1}{V}$, and derive Planck's constant.

3. Examples of Data Recording and Processing

Note: the data below are for reference purposes only, not the criteria for apparatus performance

In Tables 1 and 2, equation (8) is used to calculate the wavelength of electrons from various rings whereas *D*=256 mm, and *a*=0.40786 nm.

Table 1 Wavelength of electrons at an accelerating voltage of 12 kV

h k l	$(h^2+k^2+l^2)^{\frac{1}{2}}$	*r* (mm)	λ (nm)
111	1.732	10	0.920
200	2	11.6	0.924
220	2.828	18.5	1.042
311 (222)	3.316	21.2	1.018
400	4	28	1.115
331 (420)	4.358	32.2	1.177
422	4.9	37	1.203
511 (333)	5.196	38.6	1.183

The averaged wavelength in Table 1 is 1.073 nm, as compared to the theoretical value of 1.118 nm derived from equation (4) yielding an error of roughly 4%.

Table 2 Wavelength of electrons at an accelerating voltage of 16 kV

h k l	$(h^2+k^2+l^2)^{\frac{1}{2}}$	*r* (mm)	λ (nm)
111	1.732	9.8	0.900
200	2	11.1	0.884
220	2.828	15.8	0.890
311 (222)	3.316	18.6	0.896
400	4	24.2	0.964

331 (420)	4.358	28.5	1.042
422	4.9	32.1	1.042
511 (333)	5.196	33.7	1.033

The averaged wavelength in Table 2 is 0.956 nm, as compared to the theoretical value of 0.968 nm derived from equation (4) yielding an error of roughly 1%.