Laser Focusing System for High Brightness Polarized Electron Source for SPLEEM

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Abstract.
For construction of a high brightness polarized electron source for SPLEEM (Spin Polarized Low Energy Electronic Microscope), a new transmission type photocathode has been developed at Nagoya Univ. In our scheme, a laser light is injected from backside of the photocathode and an electron beam is emitted forward from the surface. A high numerical aperture lens with a short focal length can focus the laser lights into a small spot of photocathode. A laser spot with a diameter of 2.2μm could be achieved by our laser system, and it contributed to realize the high beam brightness of $10^5 A\cdot cm^{-2}\cdot sr^{-1}$ or more for a total current of 5μA.

Keywords: high brightness, polarized electron source, laser focus
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INTORODUCTION

Low Energy Electron Microscopy (LEEM) has been developed to observe the growth structure and morphology of ultra-thin metal film on the substrate. Magnetism information can also be provided by replacing conventional a LaB_6 or field emission gun with polarized electron gun (so called SPLEEM) [1].

For a real time observation of the above metal film growth, one image should be taken within 0.1 seconds or less, and it has been already realized by the conventional LEEM gun. On the other side, it takes more than 10 seconds by the available SPLEEM gun, and the real time observation has been impossible. In order to overcome such a dilemma, it is necessary to improve the brightness of the PES beam by two-order magnitude or more.

In the current-available SPLEEM gun, a laser light irradiates the photocathode passing through two small holes of a spin manipulator and an anode as shown in Fig. 1. It means there is a long distance between a laser focusing lens and the photocathode, and a laser spot size becomes large due to a diffraction effect. As a result, the laser spot diameter used at high energy accelerators is typically 0.1~20 mm. In order to reduce the diffraction effect, a high numerical aperture (NA) of the laser light is needed. Thus, a new laser injection scheme was proposed by us, that is, the laser light

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is injected from a backside of the photocathode and an electron beam is emitted forward from the surface, as shown in Fig.2.

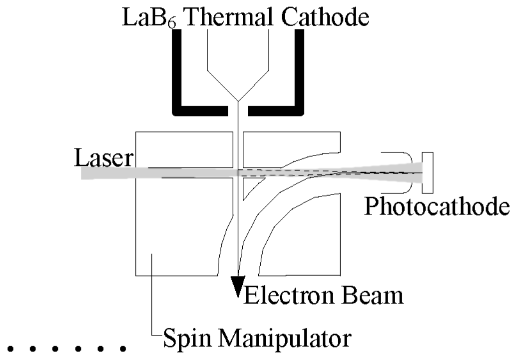

Figure 1. Standard laser injection scheme

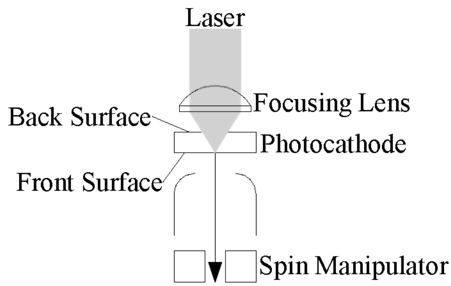

Figure 2. New laser injection scheme

DESIGN OF LASER OPTICAL SYSTEM

The design of our laser optical system is based on that developed at Hitachi for a high brightness and monochromaticity SEM [2].

The components of our system are shown in Fig. 3. The input laser light is guided to this system by a single mode optical fiber. The output light from the fiber is collimated, then converted to circularly polarized light by combination of a polarizing beam splitter and a quarter waveplate and finally focused on an active layers of the photocathode by the focusing lens (f=4.2mm, NA=0.5). The focusing lens is mounted on a translation XYZ stage to optimize the illumination conditions.

This system can monitor the laser focusing spot by using a reflected laser light from the surface of photocathode. The 180° reflected light is separated from an incident beam line by the polarizing beam splitter and focused on a CCD by an imaging lens (f=100.0mm). Combining an image magnification factor of 23.8 on the CCD and 1pixel size of 4.65μm, the resolution of this CCD monitor is 0.20μm/pixel.

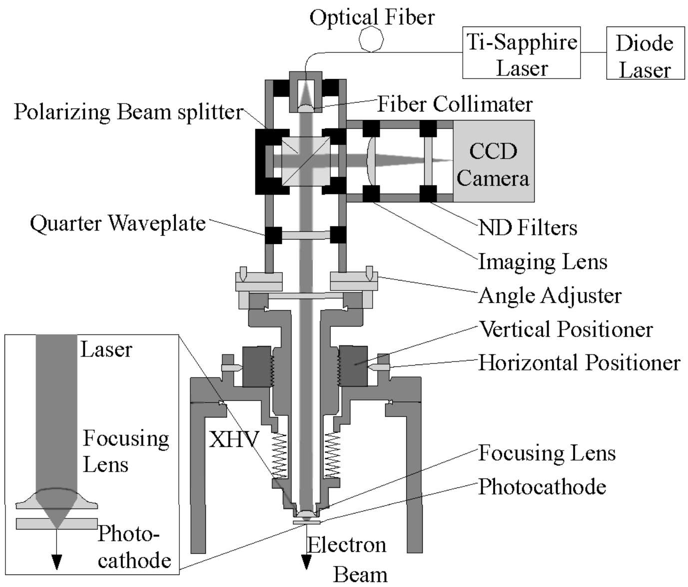

FIGURE 3. Conceptual diagram of laser optical system

EXPERIMENTAL RESULTS

Fig. 4 shows the CCD image of the optimized laser focused spot with a $1/e^2$ diameter of 2.2μm. The graphs titled X Profile and Y Profile in Fig. 5 show the projectile profiles on horizontal and vertical axes. Table 1 shows the fitting parameters of both profiles. I_0 is a peak intensity of the CCD output. X_0 and Y_0 are positions at peak intensity, and w is a $1/e^2$ radius.

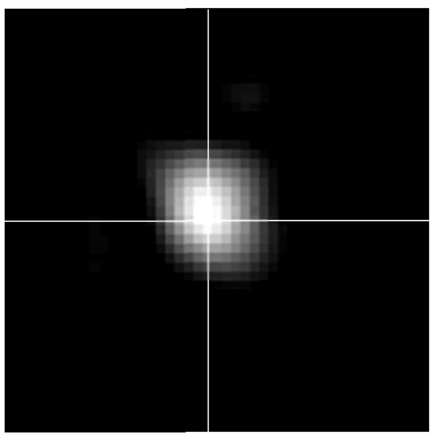

FIGURE 4. Laser spot image

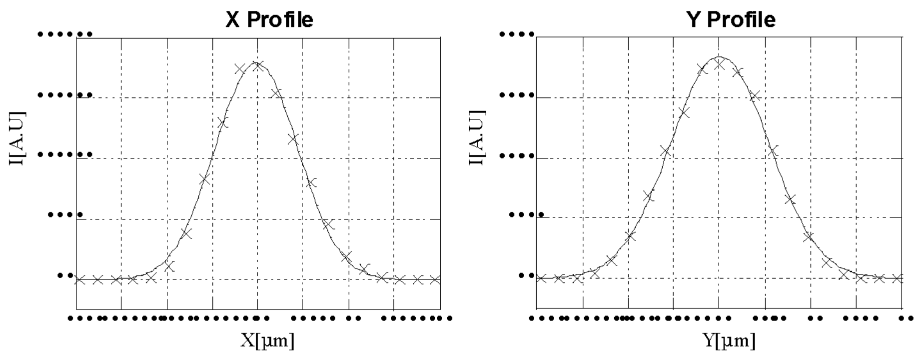

Figure 5. Laser spot profiles

TABLE 1. Fitting parameters of laser spot profiles.

	X Profile	Error$_X$	Y Profile	Error$_Y$
Fitting Form	$I_X=I_0\exp(-2*((X-X_0)/w)$^2)	NA	$I_Y=I_0\exp(-2*((Y-Y_0)/w)$^2)	NA
I_0 [A.U]	230	4	236	3
X_0, Y_0 [μm]	-0.014	0.008	0.006	0.08
w [μm]	0.91	0.02	1.08	0.02

CONCLUSION

A new type photocathode for polarized electron source for SPLEEM has been developed at Nagoya Univ. The laser light is injected from backside, transmitted through the photocathode and the polarized electrons are emitted forward from the surface. Using this transmission type photocathode, our laser optical system can shorten the distance between the focus lens and photocathode to a few millimeters and can achieve the laser spot size less than 10μm (2.2μm at minimum). This small laser spot size contributed to increase the beam brightness. For example, in case of 6.8μmϕ laser spot, the high beam brightness of 4.6×10^5A·cm^{-2}·sr^{-1} was already achieved with total current of 5μA [3].

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