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8.1 Polarized Electron Source at Nagoya University

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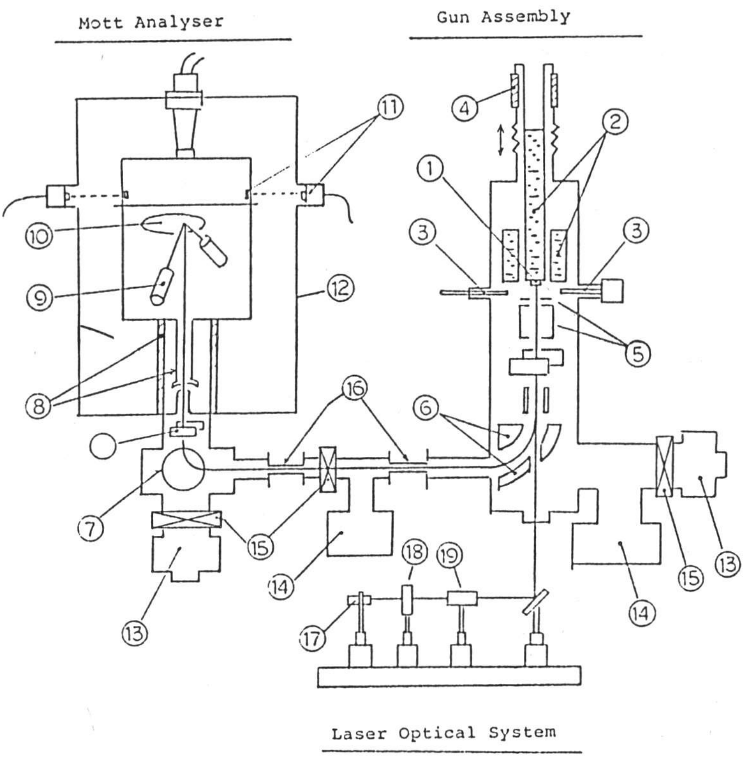
In recent years, the interest for polarized electron source (PES) has been expanding considerably, due to its wide application in basic and applied physics[1]. In early 1982, we started the project to develop PES utilizing photoemission from negative electron affinity (NEA) GaAs, at Nagoya Univ. and, at present, while our PES system is not yet completed, mechanical construction and assembling of entire system were finished. Recently we succeeded in extracting the photocurrent ($\gtrsim$ 20μA) from GaAs pumped by $\sim$1 mW laser light[2].

The schematic view of our PES system is shown in Fig. 1. The aims of this system are (i) the performance study of GaAs-based photocathodes, (ii) the feasibility study of new materials (ternary compounds with chalcoryrite structure or II-VI binary compounds with hexagonal structure etc.) which may generate polarized photo-electron beams with P $\geq$ 50%. The whole system consists of four sub-systems, (1) GaAs gun, (2) laser optical system, (3) polarization measuring system (Mott detector), and (4) electron transport system.



1 GaAs crystal
2 LN_2 container
3 Activator (O_2 and C_s)
4 5 KV ceramic bushing
5 Extraction electrode
6 Spherical condenser
7 Helmholtz coil
8 100 KV ceramic bushing
9 Surface barrier detector
10 Target foil and wheel
11 LED and photodiode
12 Freon gas tank
13 Turbo-molecular pump
14 Ion pump
15 UHV gate valve
16 Conductance adj. tube
17 Laser diode
18 Linear polarizer
19 Pockels cell

Fig. 1 Overview of GaAs polarized electron source.

To obtain NEA surface, GaAs crystal is set in a ultra-high-vacuum chamber and activated by application of Cs and O_2. Cs atoms are evaporated from a Cs-metal dispenser produced by SAES GETTERS INC. and oxygen atoms are admitted from atomosphere into a vacuum system through a heated silver tube. As a light source, we use a GaAlAs laser which produces a few mW radiation on GaAs surface. Circularly polarized light is obtained using a linear polarizer and a quarter wave retarder. For determination of electron polarization, Mott scattering is used at energies of $\sim$100 KeV. An electron liberated from GaAs cathode with an energy of a few KeV, must be accelerated up to 100 KeV at Mott Scattering chamber.

The studies of sub-system (1) $\sim$ (3) are already finished and following preliminary results have been obtained.

(1) We have studied the properties of NEA surface of GaAs in the ultra-high-vacuum chamber. The vacuum system was fully backed, and a pressure of $\sim 5\times10^{-10}$ torr reached in the vicinity of GaAs. Bu surface activation by Cs and O_2, after the heating of GaAs up to 620°C, we could obtain photo-currents whose quantum efficiencies in excess of $\sim$4% with $\sim$1mW laser light at 792 nm wave length. Although we examined two GaAs [1, 0, 0] crystals with different Zn doping of 2.3×10^{19} and 3.7×10^{18} atoms/cm^3, respectively, no significant difference was observed as for the maximum quantum efficiencies. A typical activation is shown in Fig. 2, where the photo-current is plotted as function of time.

(2) The laser optical system was also examined. A linear polarization of $\sim$98% was obtained after a dichroic polarizer and a circular polarization of $\sim$95% was achieved after a quartz quarter wave retarding plate.

(3) Mott detector system has been studied with a test beam from a hot filament rather than that from the GaAs. The pulse height spectra for the backward scattered electrons from a gold foil were obtained as shown in Fig. 3. The background could be eliminated fairly well except the small component with a nearly flat energy spectra.

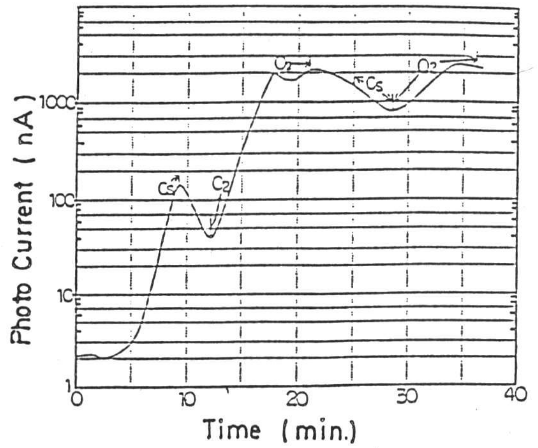


Fig. 2 A typical activation.

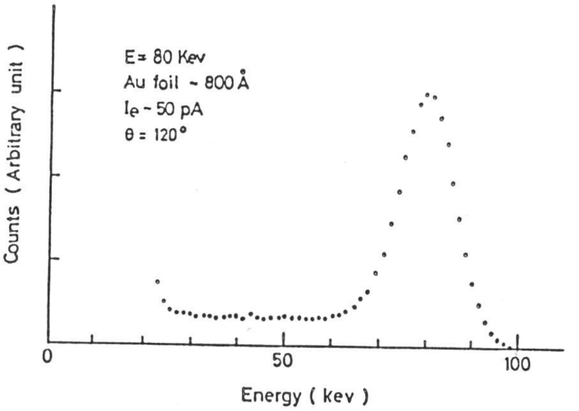


Fig. 3 Pulse-height spectra for electrons scattered at 120°.

At present, the studies of the electron beam transport system are progressed and in near future, we will be able to study the polarization of electrons from a GaAs photo-cathode, because the source and the polarization measuring system are ready for that work.

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References

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2) T. Nakanishi: KEK-Report 84-22 (in Japanese), (1985) 65 - 76.