Combined high frequency and arc plasma sources for contacts application

A.V. Leonovych[1, 2], V.S. Taran [2]

1 V.N. Karazin Kharkiv National University, Kharkiv, Ukraine,

2 Institute of Plasma Physics, NSC KhIPT, Kharkiv, Ukraine

The use of plasma sources for metal coatings is very common. Feeding large constant displacement to the metal substrate can obtain high quality coatings with excellent adhesion properties. But in this case the temperature of the sample during the coating will also be very high. This option is great in case of massive samples of solid refractory alloys such as for various kinds of cutting tools. But what if you have to work with the finer details where there is a greater probability of overheating areas? Many materials can not be used as a substrate at such temperatures because they will be destroyed. In the case of dielectric, constant displacement can not be fed in the usual manner.

So in our case there was a problem of creating the metal contacts for CVD diamond detectors of ionizing radiation. The material of the substrate is dielectric material and very sensitive to overheating. Since operating conditions can lead to heating above T = 120˚C at which standard adhesive contact starts degradation it was decided to use a connection by soldering. Due to inert properties of chromium, dual-layer contacts (chrome-stainless steel) were obtained and investigated.

EXPERIMENTAL SETUP

The application of metal contacts on to CVD diamond samples was carried out on Bulat-6 type device, additionally equipped with a high frequency generator. Fig. 1 schematically shows the device for HF-cleaning and ion-plasma assisted deposition.

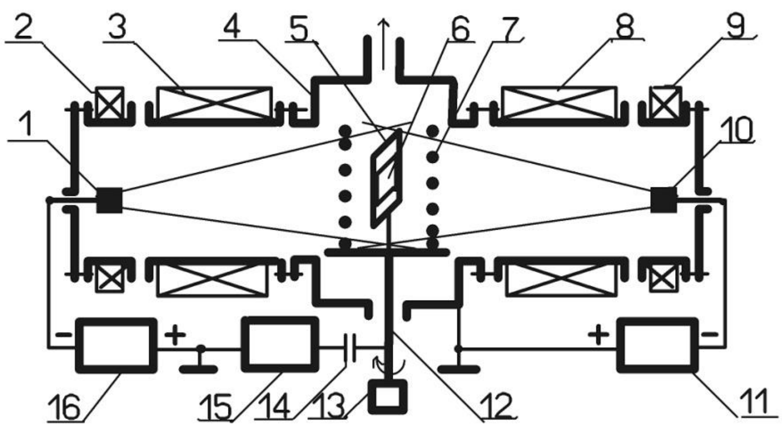

Fig. 1. Scheme of the experimental setup:

1, 10- cathode, 2, 9 - stabilizing reels, 3, 8 - focusing reels, 4 - vacuum chamber, 5 - container (lining), 6 - sample, 7 - HF antenna, 11, 16 – arcs power source, 12 - rotating device, 13 - reducer, 14 - capacitor,15 - HF generator.

Samples used for studies are polycrystalline CVD diamond on a 8×8×2 mm^3 substrate of single-crystal Si. The important point is not to allow ingress of evaporator material to the samples side surfaces. Otherwise leakage currents can occur, which is unacceptable. Therefore, the samples were placed in a fluoroplastic holder, jointly with the masks of PTFE or aluminum foils in titanium polyacetal special container. Designed container helps to fulfill the technical requirements and eventually get metal contacts of the desired geometry [1].

The sample container and the electrode with HF coils are mounted on a rotating device in the center of the vacuum chamber against the Cr and SS arc evaporators. Rotating table was connected to the HF generator via a capacitance.

Plasma method of ion cleaning is technically simple to implement but it helps us to carry out uniformity processing of any difficult form details. Also using assisted HF potential during dielectrics application helps us to eliminate the accumulation of over-discharge-surface and hence inhibition of ions that occurs at long constant-displacement potentials. An important fact is a decrease of droplet fraction formations during application due to additional ionization.

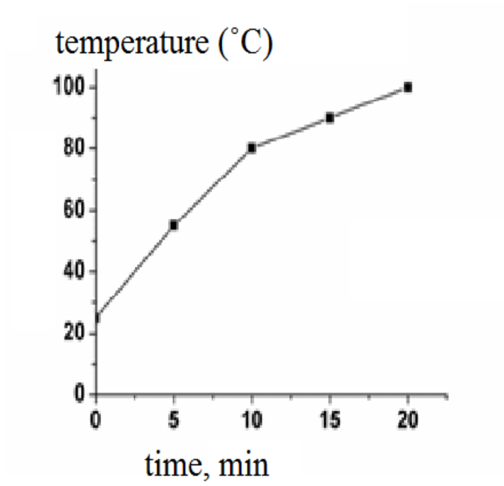

Fig. 2. Samples temperature during coatings application

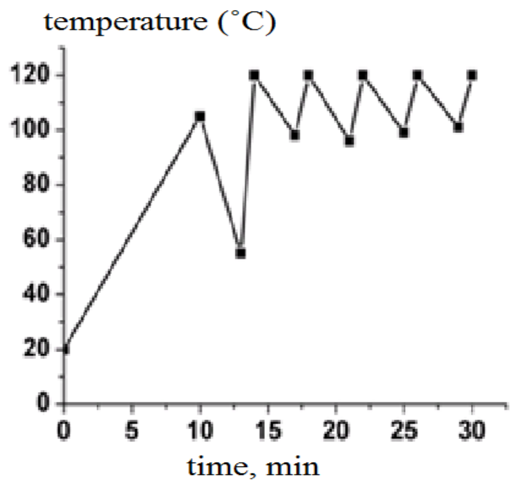

Fig. 3. The temperature of the samples during applying coatings

The important point on cleaning and applying stage is temperature monitoring. Electro and spectrometric characteristics of semiconductor detectors of ionizing radiation depends on many factors, such as, compliance with the stoichiometry of the composition, perfection of macro and microstructure, the presence of defects in a thin surface layer, the degree of perfection and electrical resistance of metal-semiconductor contacts. Exceeding the critical temperature can negatively affect all of the above.

Fig. 4. Finishing ion cleaning with HF-generator

The cleaning process starts simultaneously with rotary apparatus (Fig. 4). Neutral Ar gas inlet and supplies HF voltage to the target (sample container, HF-coil). Approximate cleaning mode: the shifting voltage U_{bias} = -(700….900) V; pressure P_{Ar}=2 10^{-1}Pa. The cleaning took 3…5 minutes, and temperature was not higher than 100 ˚C (Fig. 2).

The application of coatings starts immediately after cleaning. Cr and then SS contacts applies in a single technological cycle. A characteristic feature is pulsed operation of the evaporator on a particular program. The plasma ion method lead to heating the substrate (container with the sample) up to a temperature above permissible, therefore, there was designed a pulse mode of operation of the evaporator with switched HF voltage (assisted sputtering). In such a mode the temperature do not exceed 120 ˚C (Fig. 3). The metal layers thickness was 0.2….0.3 μm. Parameters for metal layers applying: arc current – 100 A; pulsed evaporator mode - 2 min, pause duration – 3 min, the number of cycles - 10; the shift voltage – 100 V; focusing coil current - 1.4 A; frequency of HF generator – 5 MHz. The total time of the coating is determined on the basis of the required thickness of the contact area (200…450 nm) [1,2].

RESULTS AND DISCUSSION

Table 1 shows the electrical characteristics to 7 detectors with double-layer contacts.

Tab. 1. The electrical characteristics of detectors

№	The thickness h, microns	R at 400 V after application double-layer contacts, Ohm	counting rate, counts / s
1	224	2,0E+12	13,2
2	191	2,0E+12	9,6
3	220	2,4E+12	8,6

4	216	4,7E+11	4,8
5	182	1,5E+12	9,8
6	150	3,2E+12	13
7	229	2,2E+12	15,4

In Fig. 5 it is shown the CVC of two samples with the smallest and largest value of electrical resistance.

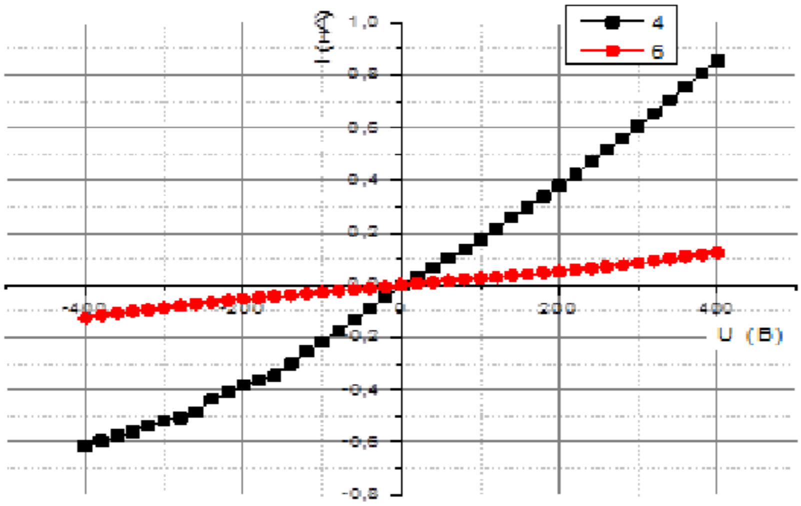

Fig. 5. CVC of two samples with the smallest and largest value of electrical resistance.

Samples that have a linear CVC with minimal leakage current can be used as detectors of ionizing radiation. Registration of the pulse-height distributions of the detector signal under α irradi-ation from ^{239}Pu source performed with the following parameters of spectrometric tract: U_{bias} = 400V, the shaping amplifier gain - 1000, shaping time τ = 1 microsecond, acquisition live time - 60 minutes.

REFERENCES

1. R.M. Muratov, A.A. Vierovkin, V.E. Kutny, Yr.N. Nezovibat'ko, A.V Rybka, V.S. Taran.Development and application of metal contacts on polycrystalline diamond films using combination of HF and ARC plasma sources // InternationalConference-School on Plasma Physics and Controlled Fusion,Kharkov, 2014, p.158.
2. R.M. Muratov, A.A. Vierovkin, V.E. Kutny, Yr.N. Nezovibat'ko, A.V Rybka, V.S. Taran.Development and application of metal contacts on polycrystalline diamond films using combination of HF and ARC sources // VANT "Series Plasma Physics(), №7, pp.188-190, 2014.