Recent progress at pulsed dc systems at CERN

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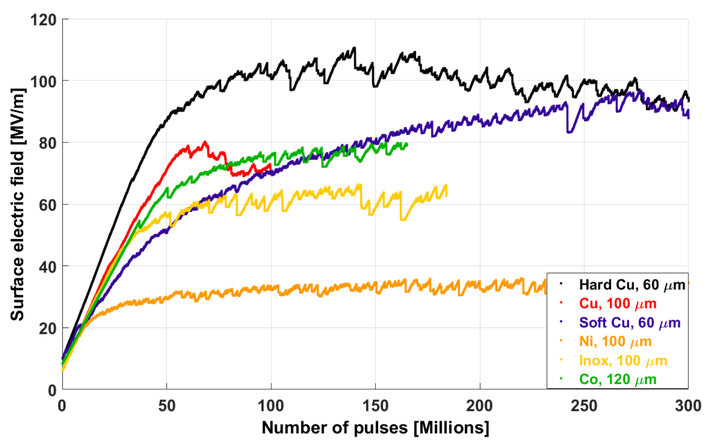
Overview

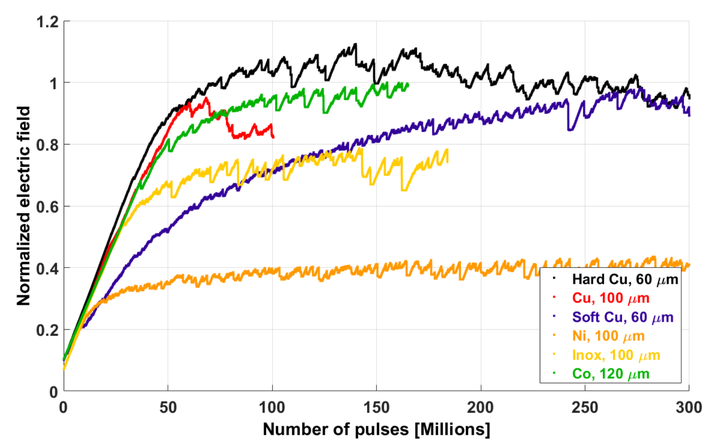
Pulsed DC systems dedicated to the study of electrical breakdown phenomenon and the conditioning process are part of the CLIC (Compact Linear Collider) project. There are two pulsed DC systems operational at CERN, as well as similar systems at Helsinki and Uppsala Universities. In the systems, two plane electrodes with large surface areas are placed parallel to each other with a separation of tens of micrometers, under a high vacuum. The experimental results from the field emission current measurements, conditioning of different materials are presented.

Material information

No.	Material	Information
1.	**Hard Cu**	OFE copper, as-machined using fly-cut and diamond turning, roughness 30 nm.
2.	**Cu**	OFE copper, as-machined using fly-cut and diamond turning, heated up to 800°C in hydrogen atmosphere.
3.	**Soft Cu**	OFE copper, as-machined using fly-cut and diamond turning, heated up to 1040°C in hydrogen atmosphere.
4.	**Ni**	99.5% Ni, roughness is around 400 nm.
5.	**Inox**	Steel alloy, 16.73% Cr, 10.13% Ni, 2.04% Mo, 1.54% Mn and 1.51% others.
6.	**Co**	99.9% Co, roughness is around 800 nm.

Conditioning comparison





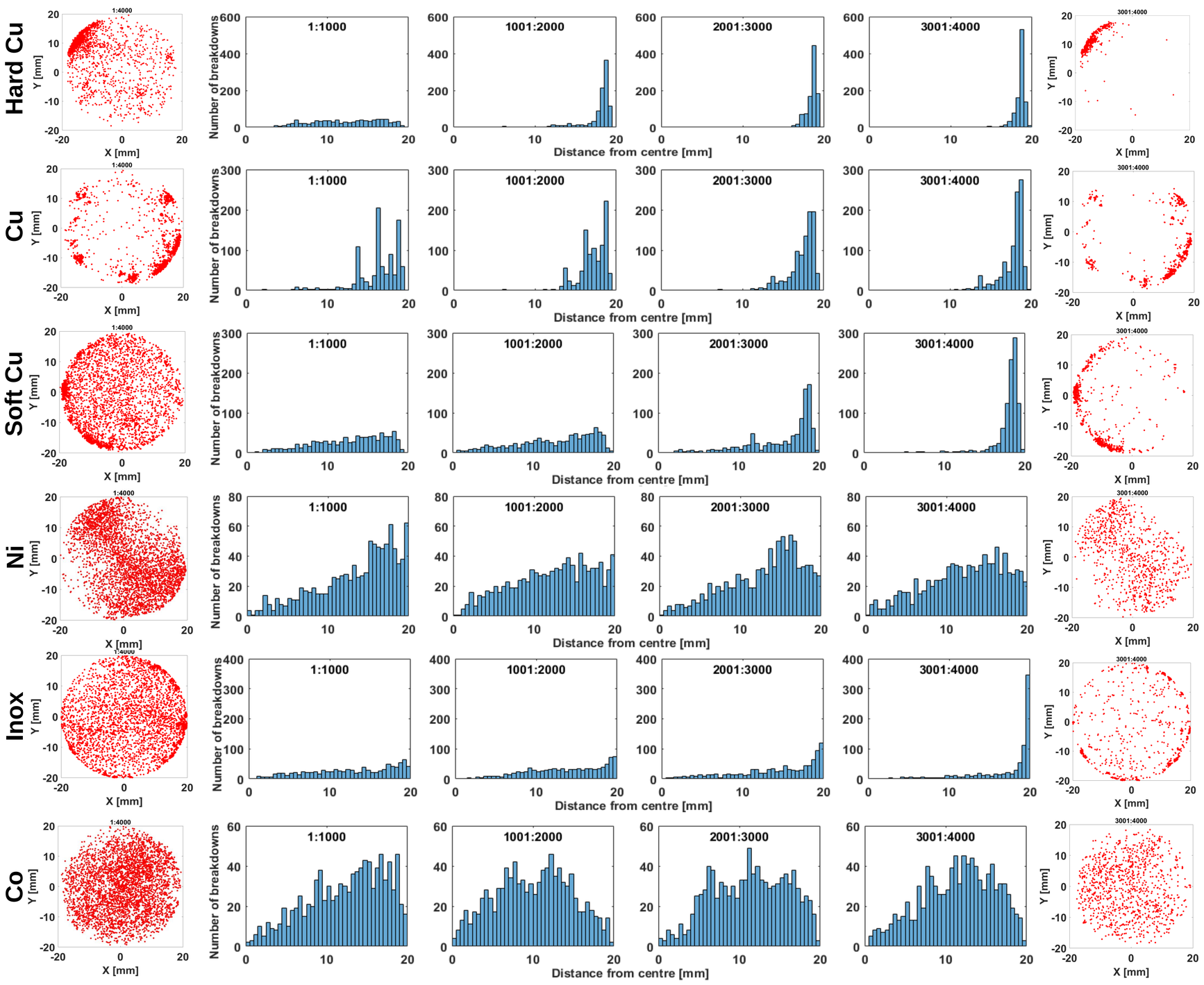
For initial conditioning pulsing done with feedback algorithm similar to RF test [1, 2] with 1 μs pulse width. To compare conditioning for the electrodes tested with different gaps the next equations are used:

$$E_{surf} = \frac{V}{d}$$

$$E_{norm} = \left(\frac{V}{V_{max}}\right) \times \left(\frac{d_{max}}{d}\right)^{0.7}$$

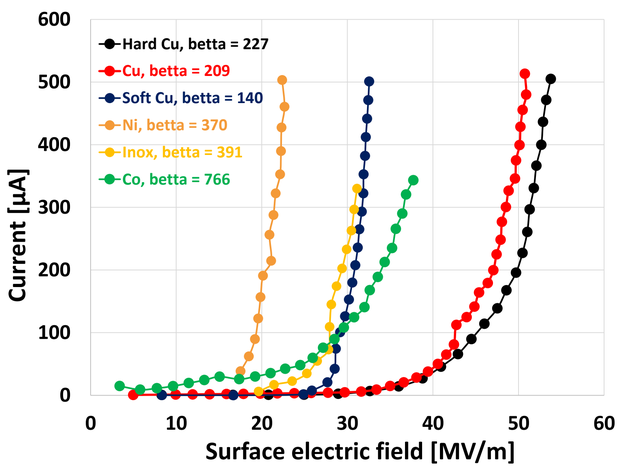
where V_{max} is a maximum voltage reached during test for all electrodes, d_{max} - maximum gap distance between electrodes over all tests with the different materials, V and d – voltage and gap distance, respectively, during specific test. Factor 0.7 is experimentally approved in pulsed dc system [3] and consistent with other sources [4].

Evolution of breakdown distribution



Evolution for the first 4000 breakdowns during the high-voltage test with various materials.

Field emission



Conclusions

1. Pulses dc systems available studying of materials for the accelerating structures and high-voltage applications.
2. Additionally to copper treated in different way, nickel, Inox and cobalt were tested.
3. Comparison of the conditioning behavior for the mentioned materials showed that all copper earlier of later succeed the similar level of electrical field. Cobalt reach similar to copper result for the normalized electric field.
4. The breakdowns are started occur more likely on the edge of the surface further over the test.
5. The evolution of breakdowns distribution over the electrode surface for nickel and cobalt is notable different that for other materials. The breakdowns are spread over full electrodes radius.

References

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