Electrical and Pressure Characteristics of Wire Explosions of Various Wire Types to Simulate Reactivity Initiated Accident (RIA)

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Ⅰ. Abstract

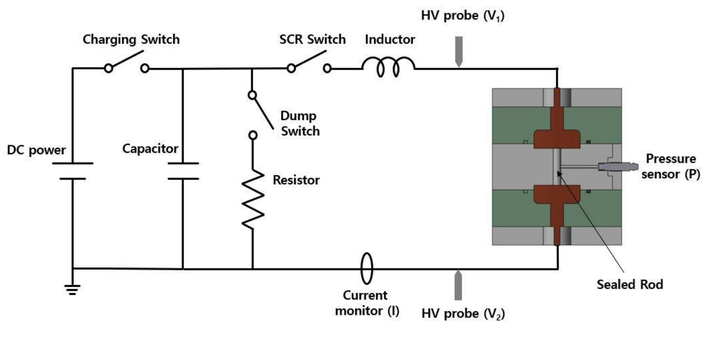
Reactivity Initiated Accident (RIA) occurs when fission rate and reactor power increase beyond the limit. To establish safety regulation for RIA, a number of experiments have been carried out since CABRI test in 1993, such as NSSR, TREAT, IGR. As a part of a Nuclear Safety and Security Commission (NSSC) project, we have conducted wire-explosion test to imitate mechanical behavior of cladding during RIA situation. Wire-explosion is a way of generating plasma and accompanies shock waves. Various experiment to simulate RIA under different wire, capacitance, and voltage were conducted.

Ⅱ. Objectives

- Investigate electrical and pressure behavior at wire explosion under different wire, capacitance, and voltage.
- Improve the condition of the experiment to simulate reactivity initiated accident(RIA).

Ⅲ. Methods

- Schematic diagram of pressure simulation instrument

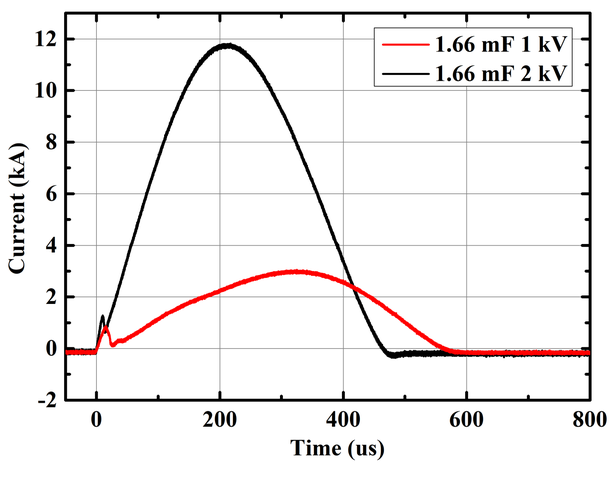


- Capacitance: 0.83 mF-2.49 mF
- Charging Voltage: 1-2.5 kV
- Wire diameter: 100, 125, 200 um
- Wire material: Copper, Tungsten, Aluminum
- Wire length: 50 mm
- Current: 3025, Pearson
- Voltage: P6015A, Tektronix
- Pressure: 109C12, PCB Piezotronics

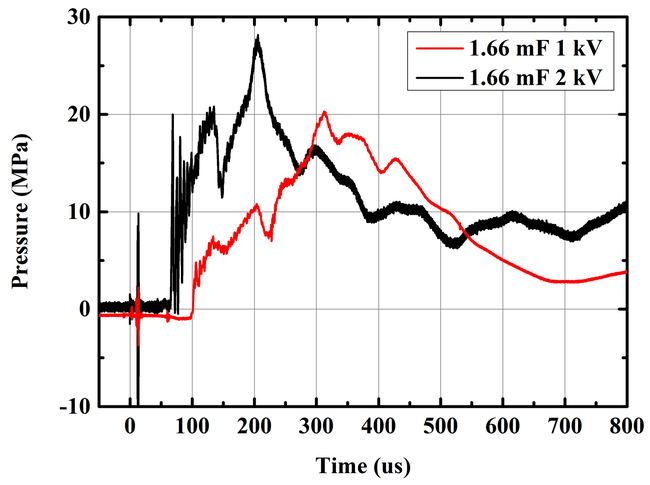
- The voltage, the current, and the pressure are measured by HV probes, the current monitor, and the high pressure sensor.

Ⅳ. Results

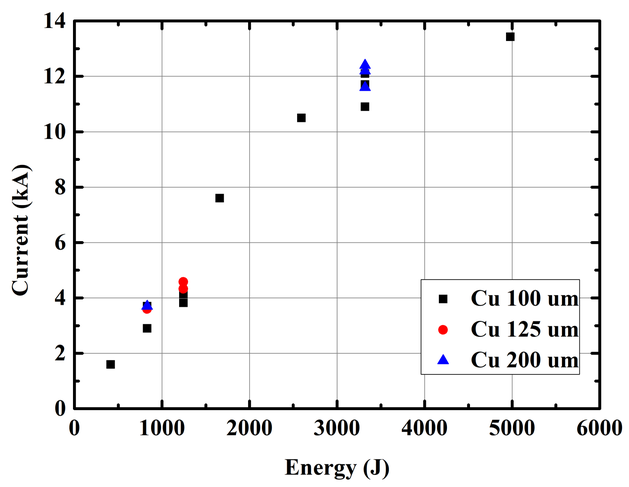
1. Current and pressure dependence on charging voltage and stored energy



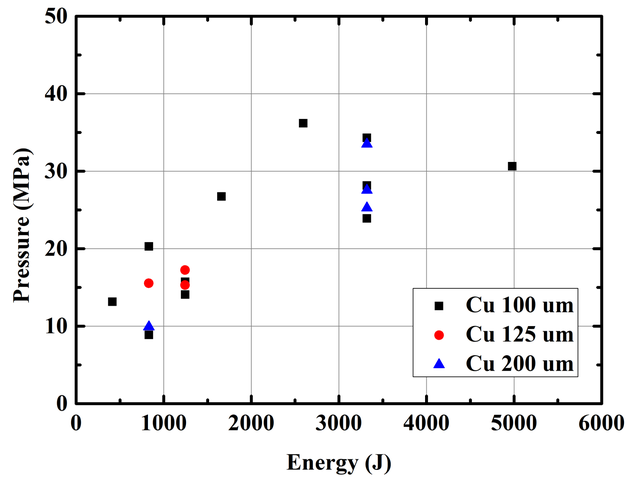
Comparison of current at different charging voltage



Comparison of pressure at different charging voltage



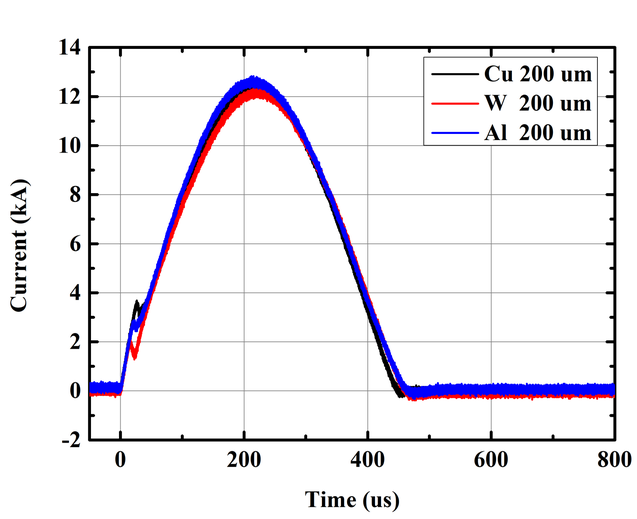
Peak current dependence on stored energy



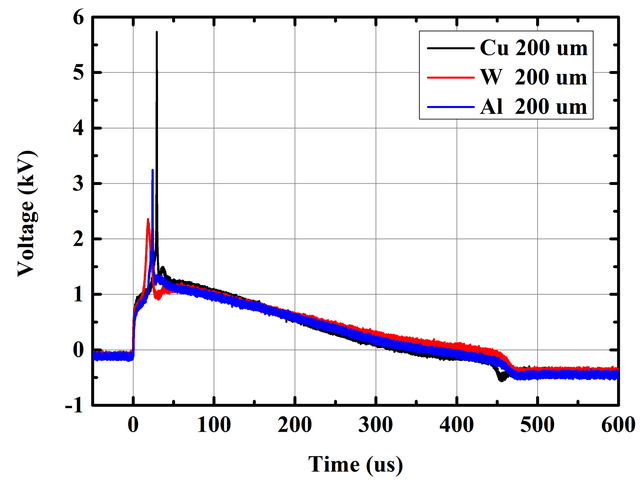
Peak pressure dependence on stored energy

- Higher charging voltage leads to the higher peak and faster rising time
- Doubling voltage leads to increasing peak current by 4 times, as the stored energy is 4 times higher
- Doubling voltage leads to increasing peak pressure, however, it seems that peak pressure is not linearly dependent on stored energy
- Increasing stored energy leads to higher peak current and peak pressure, regardless of wire diameter

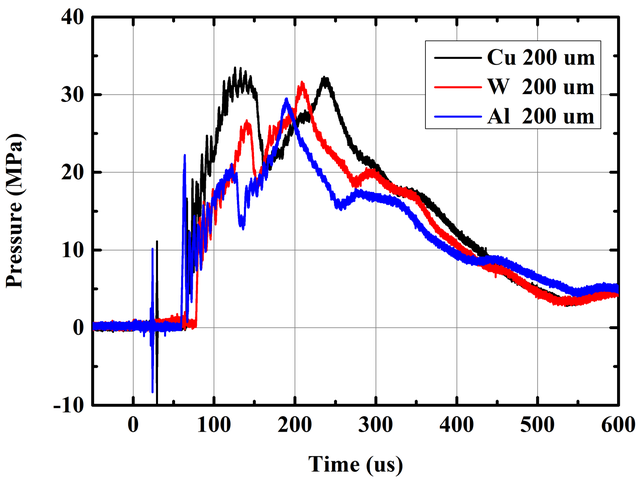
2. Current, voltage, and pressure dependence on material



Comparison of current shape at different material properties



Comparison of voltage shape at different material properties



Comparison of pressure shape at different material properties

- First peak at the voltage and the current varies with material, as first peak depends on physical properties such as melting point, boiling point, and specific heat.
- After the first peak, however, overall shape of the voltage and the current seems similar, leads to similar delivered energy on wire
- The peak pressure does not show a significant difference as the delivered energy is similar

Ⅴ. Summary & Future Works

Summary

- Confirmed that the higher stored energy leads to higher peak current and peak pressure
- Peak current is linearly dependent on the stored energy, however, peak pressure is not linearly dependent on the stored energy
- Material does not result in difference at the peak pressure

Future Works

- Applying fast camera technology, observe the difference at wire explosion with different wire material and diameter
- Find optimization point of wire explosion to achieve target peak pressure

Ⅵ. Acknowledgement

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