

Pulse Plasma Rock Fragmentation Technology



May 20, 2019

KAPRA (Korea Accelerator and Plasma Research Association)





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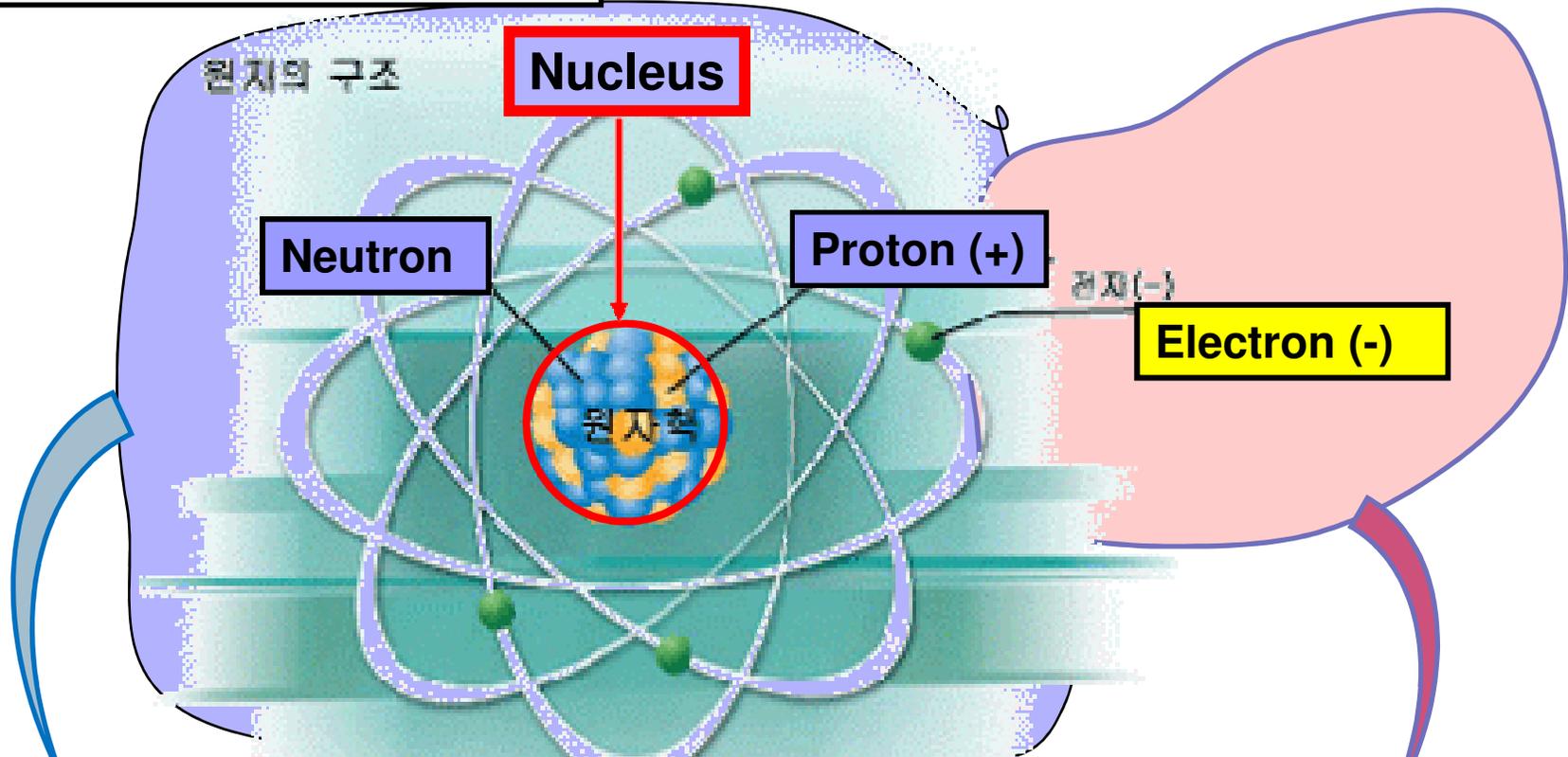
I. What is Plasma?

II. Pulse Plasma Technology

III. Video

I. What is Plasma?

1. Structure of an Atom



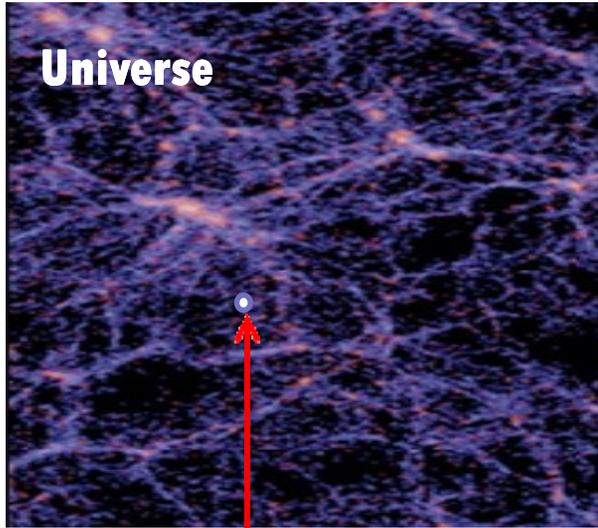
Plasma State : Ionized Form

Positive Ion (Cation)

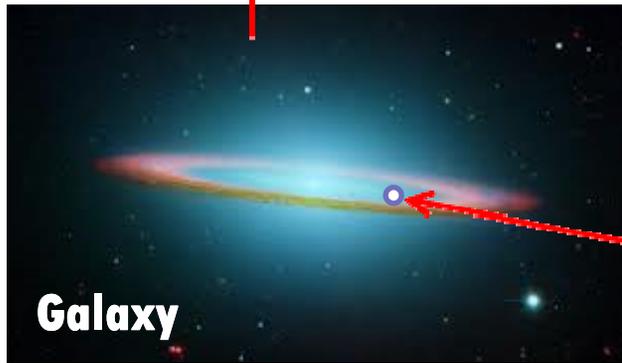
Negative Ion (Anion)

I. What is Plasma?

2. The Universe is filled with Plasma.



99% of the Universe is Plasma state



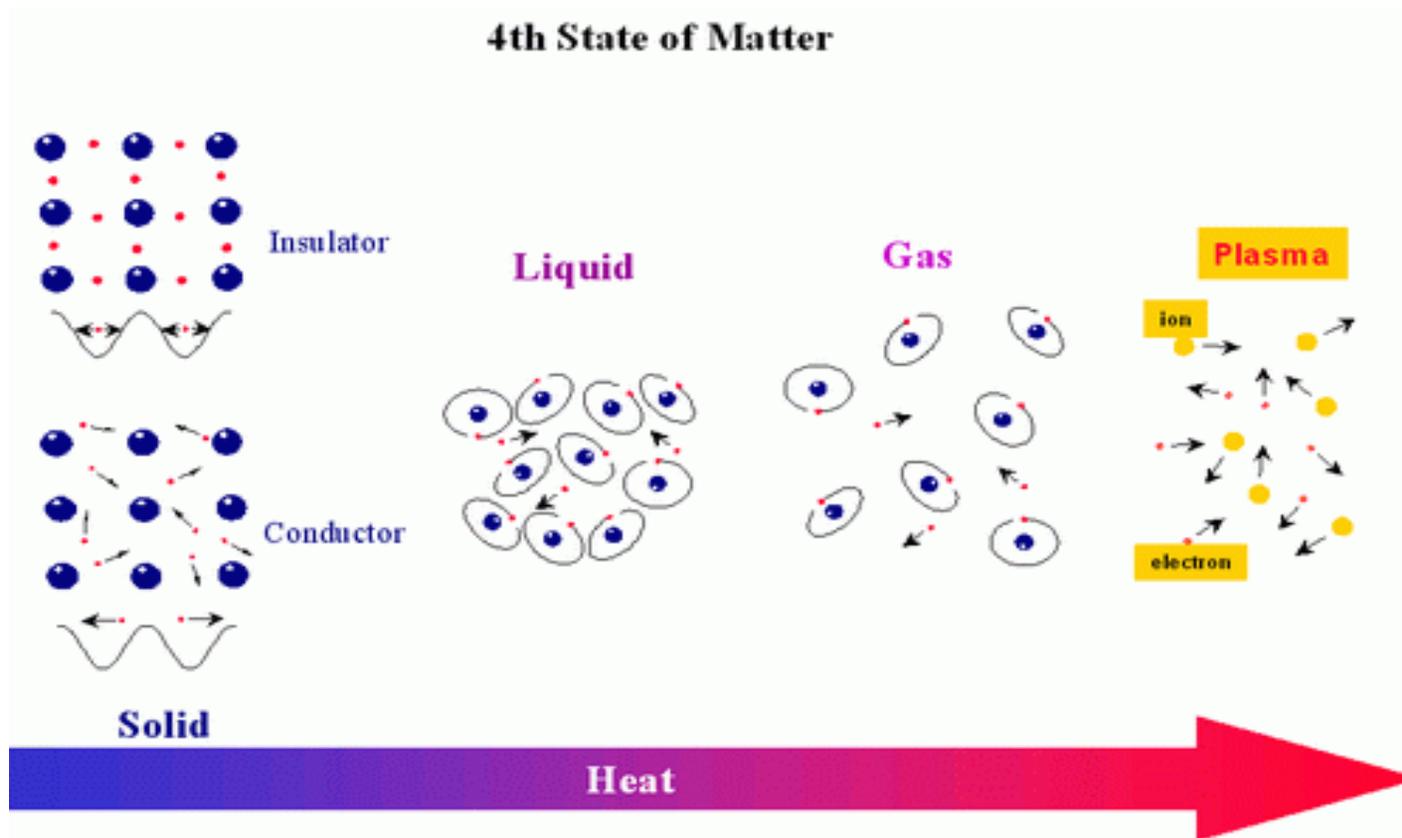
150,000 light year distance



The Earth

I. What is Plasma?

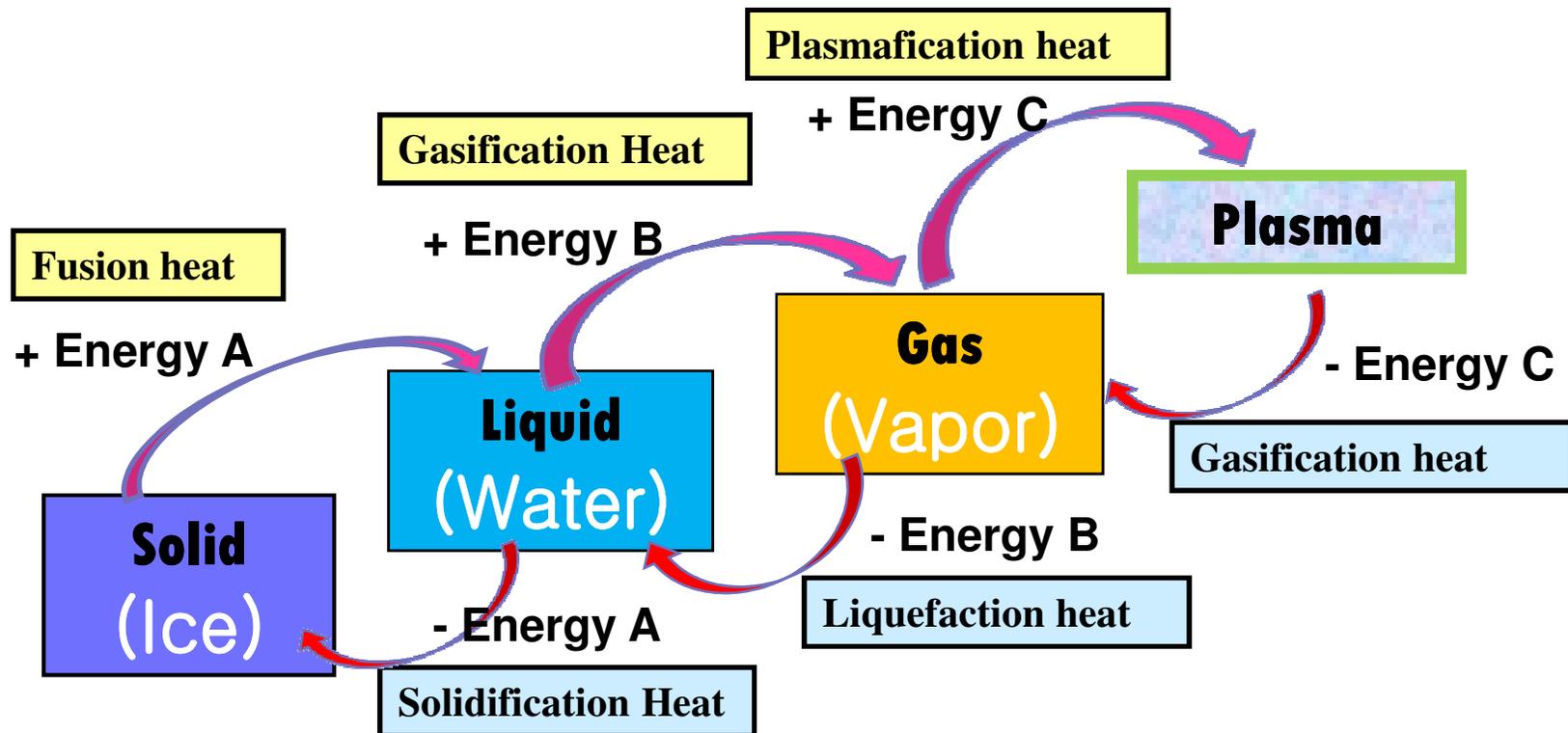
3. Transformation of States of Matter



I. What is Plasma?

4. Pulse Plasma Rock Fragmentation technology

Pulse Plasma Rock Fragmentation technology is to utilize the energy (Heat or Pulse Wave or Pressure) which comes out during state change of a matter



1. EPI Development History

1) Construction Market needs environmental friendly products

- Low Noise, Low Vibration, No Harmful noxious gas

2) Advanced countries' research.

- Noranda, Canada / Maxwell, USA / TZN, Germany / KAPRA, Korea

3) Korea : KAPRA succeeded in commercialization of the technology of Pulse plasma rock fragmentation system in 1998

- 2004~ : Exhibited BAUMA International Construction Machinery Fair
Received good reputation
- It became a time-proven technology
- 16 patents are embedded in this technology. (Difficult to copy)

II. EPI TECHNOLOGY

2. EPI technology is to solve following obstacles

- 1) **How to make a special capacitor**
(To store big energy)
- 2) **How to make a special cable which can**
(Cary the high pulse power)
- 3) **Find “Plasma generating material”**
(Economical, Effective, Environment-friendly)

Applicable in the construction

II. EPI TECHNOLOGY

2. 1) How to make a special capacitor to store big energy



Input	1) 380V AC 3Ph 2) 2) 20 kW Gen.	Max. Charge V.	9 kV DC Capacitor x 8ea (Parallel Connection)
Stored Energy	267 kJ	Max . Discharge Energy	◆ 134 MW

II. EPI TECHNOLOGY

☞ Energy Calculation (Stored energy, Discharged Energy)

※ Calculation of storage energy of capacitors; Hopkins theory

$$\bullet \frac{1}{2} cv^2 = \frac{1}{2} \times 0.83 \mu F \times (9,000v)^2 \times 8ea = 268.92kJ$$

※ Calculation of discharged energy

- 1) Charge 20kW electric power to the capacitors for 13 seconds
- 2) Discharge the stored energy in 2ms

From Energy conservation law, $P = 1) = 2) = \text{Constant}$

$$W_1 \times s_1 = W_2 \times s_2$$

$$(20kW) \times 13s = W_2 \times 2ms$$

$$W_2 = 130MW \text{ (Pulse Power Energy)}$$

II. EPI TECHNOLOGY

2. 2) How to make a special cable which can carry (the high power)



Litz wire for high power current carrying

II. EPI TECHNOLOGY

2. 3) Choose Materials Generating Plasma

- Environment-friendly
- Economical
- No Toxic Gas

Metal	Kcal /g	Kcal /ml
Be (beryllium)	8.62	16
B (boron)	4.50	10.5
Al (aluminum)	3.61	9.75
Mg (magnesium)	3.12	5.42
Li (lithium)	1.79	4.03
Ti (titanium)	1.70	7.66

Al – High energy generation per unit

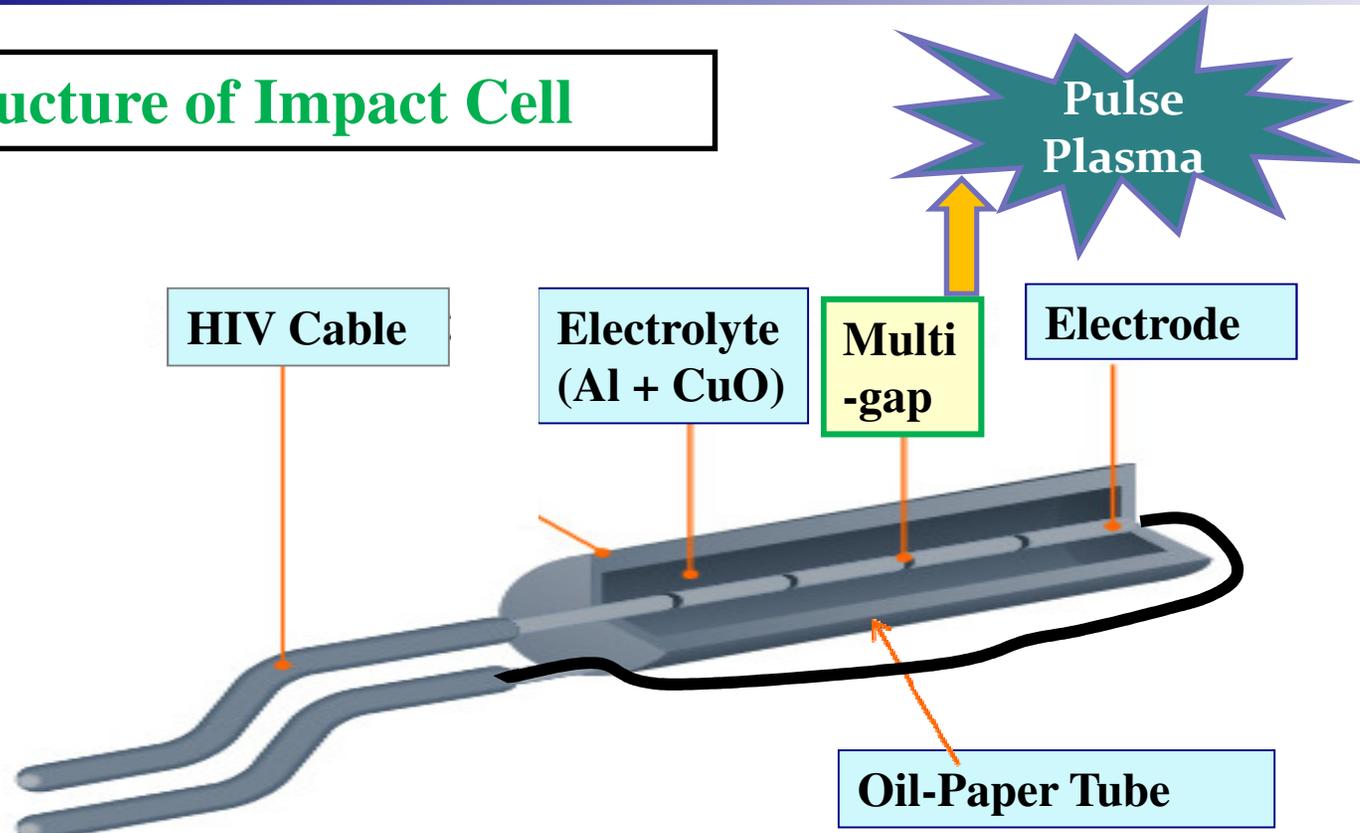
- No gas generation when react with copper oxide
- Low price compared to other metals, easy to purchase

Al : Aluminum Powder Coated with wax

CuO : Copper Oxide Powder



2. 4) Structure of Impact Cell



When an extremely high voltage and current is discharged to the multi-gap inside the cell in milli-seconds, the electrode generates high heat by the electrical resistance. By the heat, molecules and atoms of the aluminum and copper oxide, become plasma state and bring Thermite reaction, which produce very high heat and pressure and break the rocks.

II. EPI TECHNOLOGY

3. EPI Pulse Plasma Rock Fragmentation Process



① Drilling



② Cell insert – Stemming



③ Cable connecting



④ Mat covering



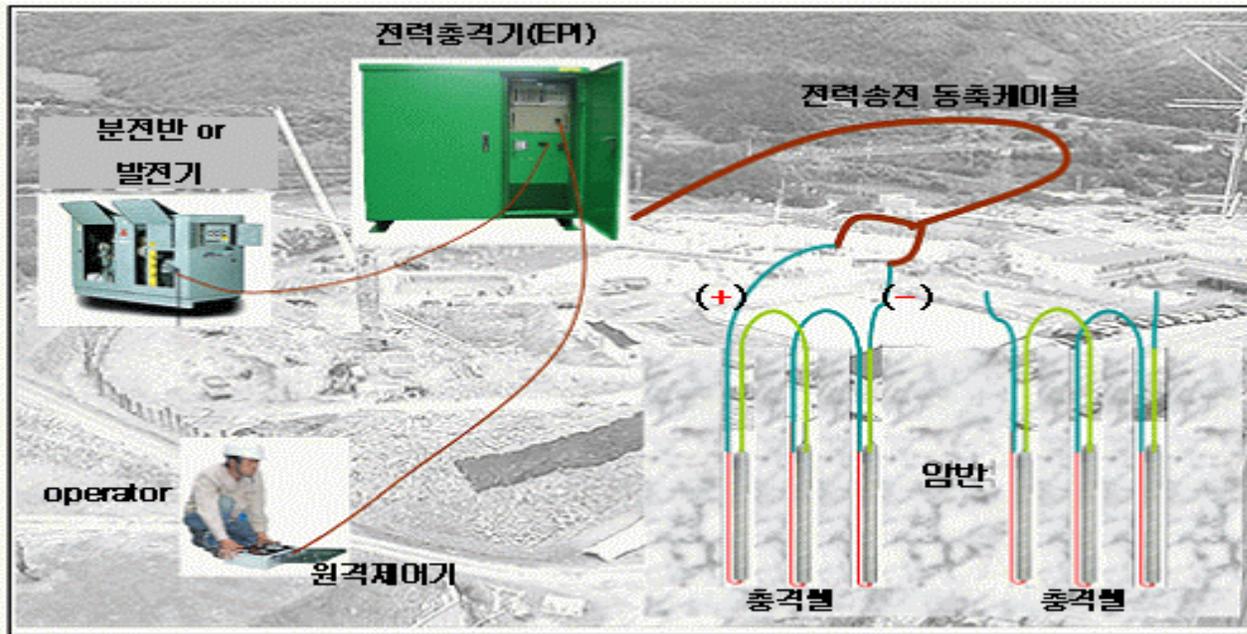
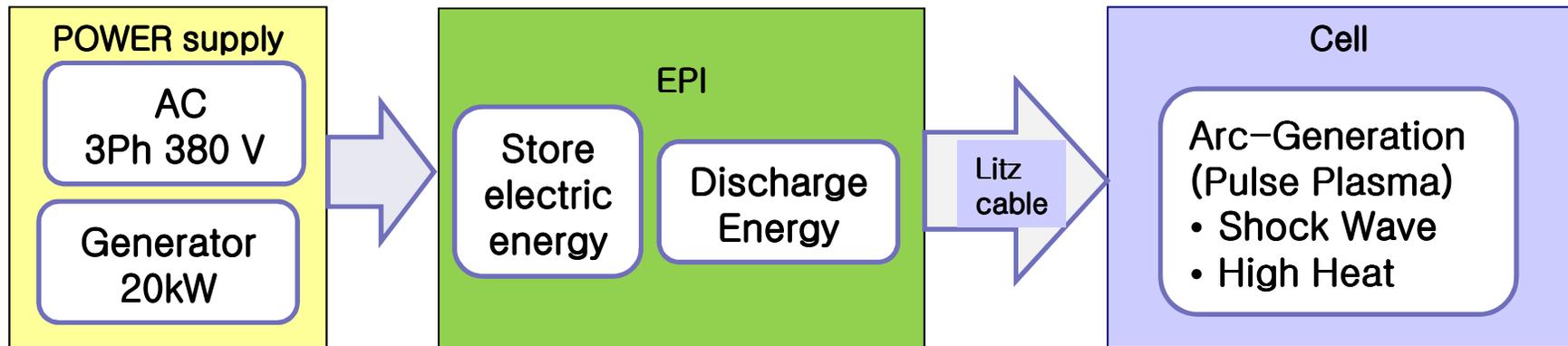
⑤ Charging –Discharging
(can control every shot)



⑥ Fragmentation

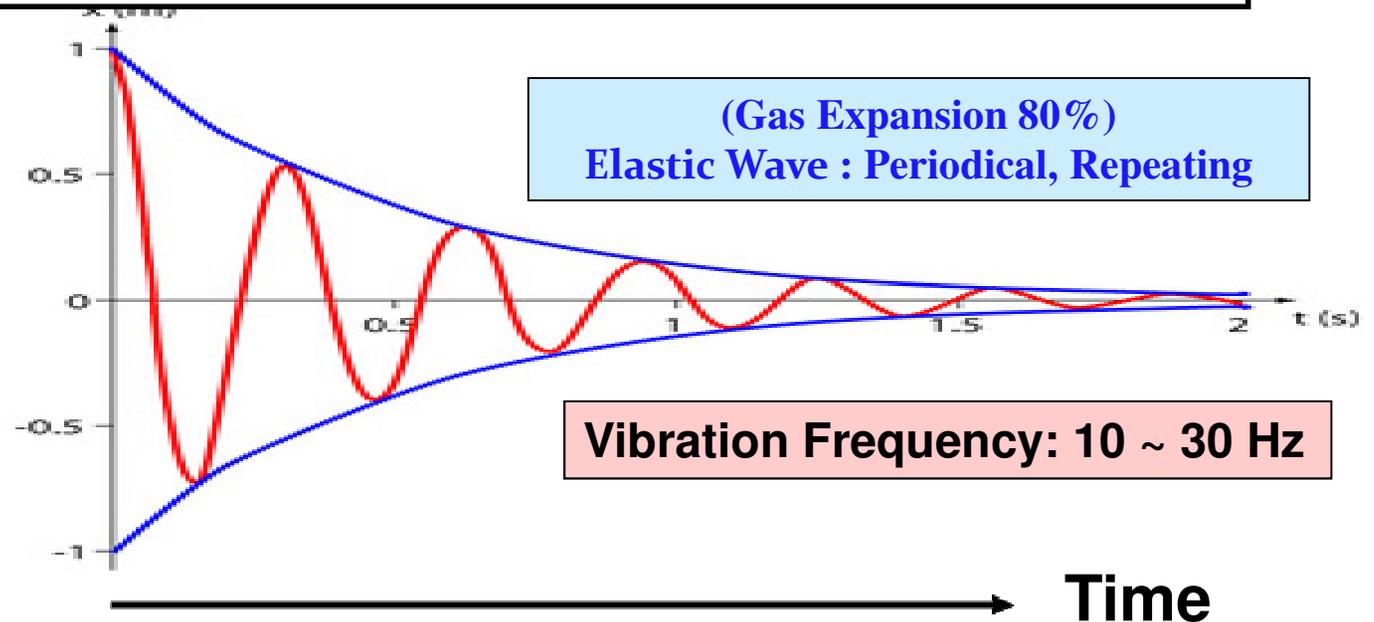
II. EPI TECHNOLOGY

3. EPI Pulse Plasma Rock Fragmentation Process

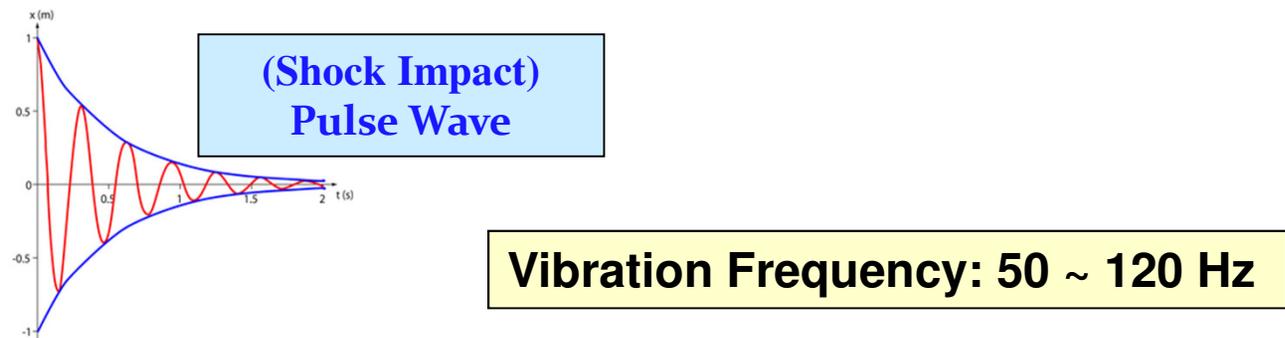


4. Attenuation of Vibration and Sound vs time

**Explosives
(Gun-powder)**



**Plasma
(Impact Cell)**



Ref.: Natural Frequency of Building : 5 ~ 30 Hz

II. EPI TECHNOLOGY

5. Comparison (Explosive vs EPI Impact Cell)

	Explosives (Gun-powder)	EPI Pulse Plasma
Reaction Formula	$2\text{NH}_4\text{O}_3 \rightarrow 4\text{H}_2\text{O} + \text{N}_2 + \text{O}_2 + 238\text{kJ}$ (Solid) (Water) (Gas) (Gas) (Energy)	$2\text{Al} + 3\text{CuO} \rightarrow \text{Al}_2\text{O}_3 + 3\text{Cu} + 1,197\text{kJ}$ (Solid) (solid) (Solid) (solid) (Energy)
Weight	Weight : 160kg	Weight : 292.6kg
Gas Generation	$\text{N}_2, \text{O}_2, (980 \text{ l/kg})$	None
Temp.	Liquefaction : 169°C	Liquefaction : 2,850°C (Hard to detonate)
	Explosion : 1,300°C	Thermite : 3,000°C
Energy Rock Breaking	Gas Pressure : 80% Shock wave : ~20%	Shock Wave : 80% Heat Pressure : 20%
Vibration Band	10 ~ 30Hz (Easy resonance with building)	50 ~ 120Hz (No resonance with building)
Wave	Elastic Wave : Periodical, Repeating	Pulse Wave >> Gas Pressure

II. EPI TECHNOLOGY

6. Test result of Vibration, Sound (EPI Plasma/Explosives)

◆ Tested 3 time each 20/30/40m distance

1. Vibration Velocity

Kine: (cm/s)

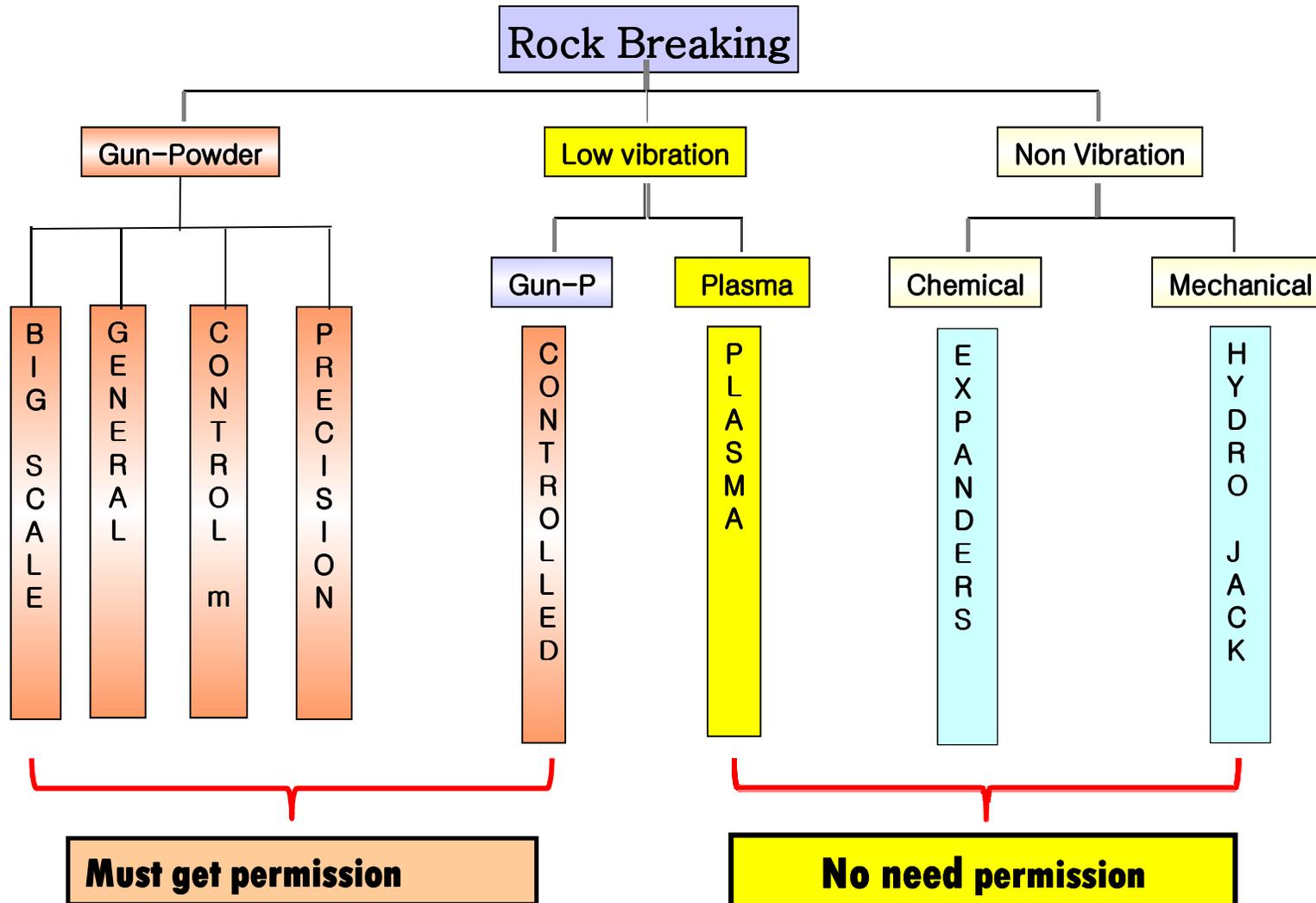
Distance	EPI (Avr. Vibration)	Explosives (Avr. Vibration)	EPI / Explosives
20M	0.092 kine	1.80 kine	1/20
30M	0.089 kine	1.15 kine	1/13
40M	0.047 kine	0.575 kine	1/12

2. Sound Level

Distance	EPI (Avr. Sound level)	Explosives (Avr. Sound level)	EPI / Explosives
20M	67.6dB	83.2dB	1/36
30M	65.3dB	78.9dB	1/23
40M	63.8dB	73.3dB	1/9

※ The difference of 10dB is about 10 times difference in the sound level. The difference between 70dB and 80dB is 10times. The difference between 70dB and 90dB is 100 times

7. Governmental Regulation



Video Presentation