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ASELSAN is a Turkish Armed Forces Foundation company.

DEVELOPMENT OF LOW ENERGY ELECTRIC INITIATOR

61st Annual Fuze Conference
May 15th, 2018
Berkay AKYAPI & Cemil YILMAZ
ASELSAN

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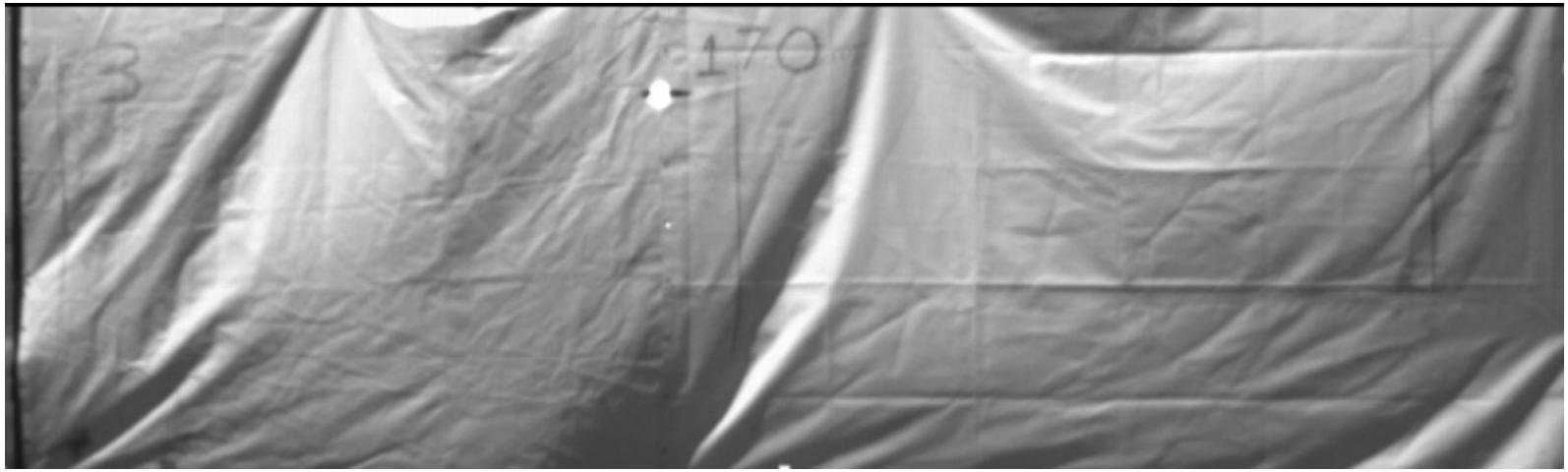
- Electric Initiator Usage
- Comparison
- Components
- Characteristics
- Qualification Tests
- Conclusion and Future Work

- One of the most important requirements for an ammunition is its explosion in the specified time and reliability. The unit that initiates the reaction is called Electric Initiator.
  - Initiation of energetic explosive mixture by use of electro thermal heat obtained through thin film chip.
  - Starting element of the explosive train.
  - Accuracy, low energy, short function time



ASELSAN's 35 mm Air Burst Ammunition's explosive chain reaction

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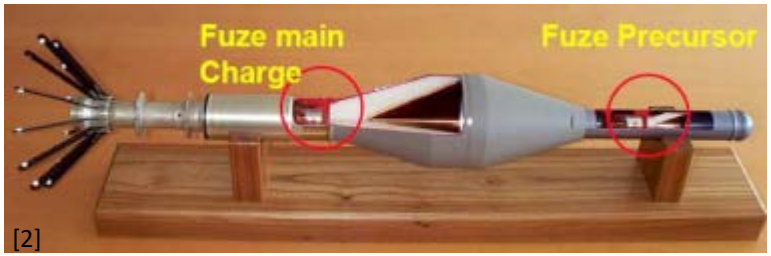
MILITARY APPLICATIONS

- Smart munitions,
- Ejection systems,
- Pyro components,
- Missiles


[1]


[3]



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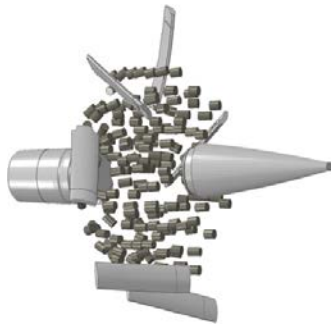
ASELSAN's 40 mm High Velocity Smart Grenade


ASELSAN's 35 mm Air Burst Ammunition

CIVIL APPLICATIONS

- Automotive safety (airbags, seat belts)
- Space applications (separators, explosive bolts)
- Mining (rock extraction)
- Industry (demolitions)

[2]

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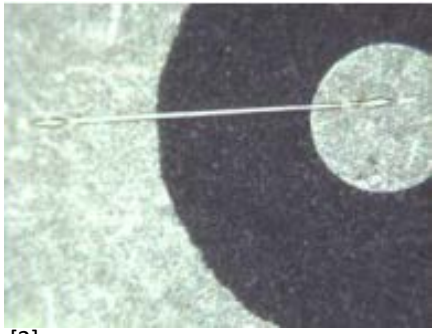
[5]

Comparison with Bridge Wire

- Classic technology uses bridge wire instead of thin film initiator chip.
- This low cost initiators are produced since many years.
- Bridge wire initiators have many types and different sizes.
- But these products have disadvantages
  - Limited all-fire values, to obtain low energy initiators it has to use ultra fine(<10 micron) bridge wire
  - Difficult welding process and controlling resistance value
  - Not suitable for high shock, vibration and spin applications, e.g. smart munitions

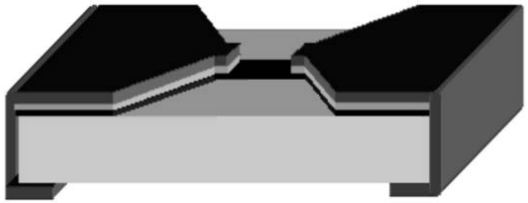
[6]



[2]

New technology uses thin film initiator chip to activate energetic materials.

Advantages	Disadvantages
Low firing energy	Cost
Low firing time	Need ESD filters
High [no fire/all fire] ratio	Need specific headers for soldering or bonding
Easy manufacturing, using automatic reflow-machines	Standart surface month resistors can be difficult for tiny initiators
Almost constant resistance value	
Withstands difficult environmental conditions	
Suitable for high accelarations and spin rates	



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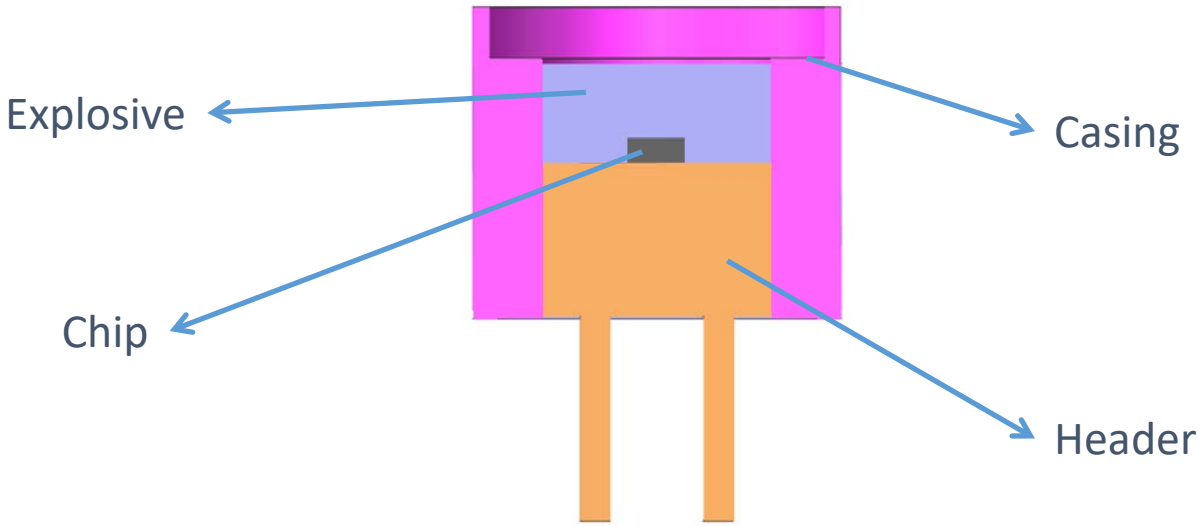
Electric Initiators are mainly composed of

- Glass to Metal Seal Header
- Thin Film Initiator Chip
- Explosive Mixture
- Casing



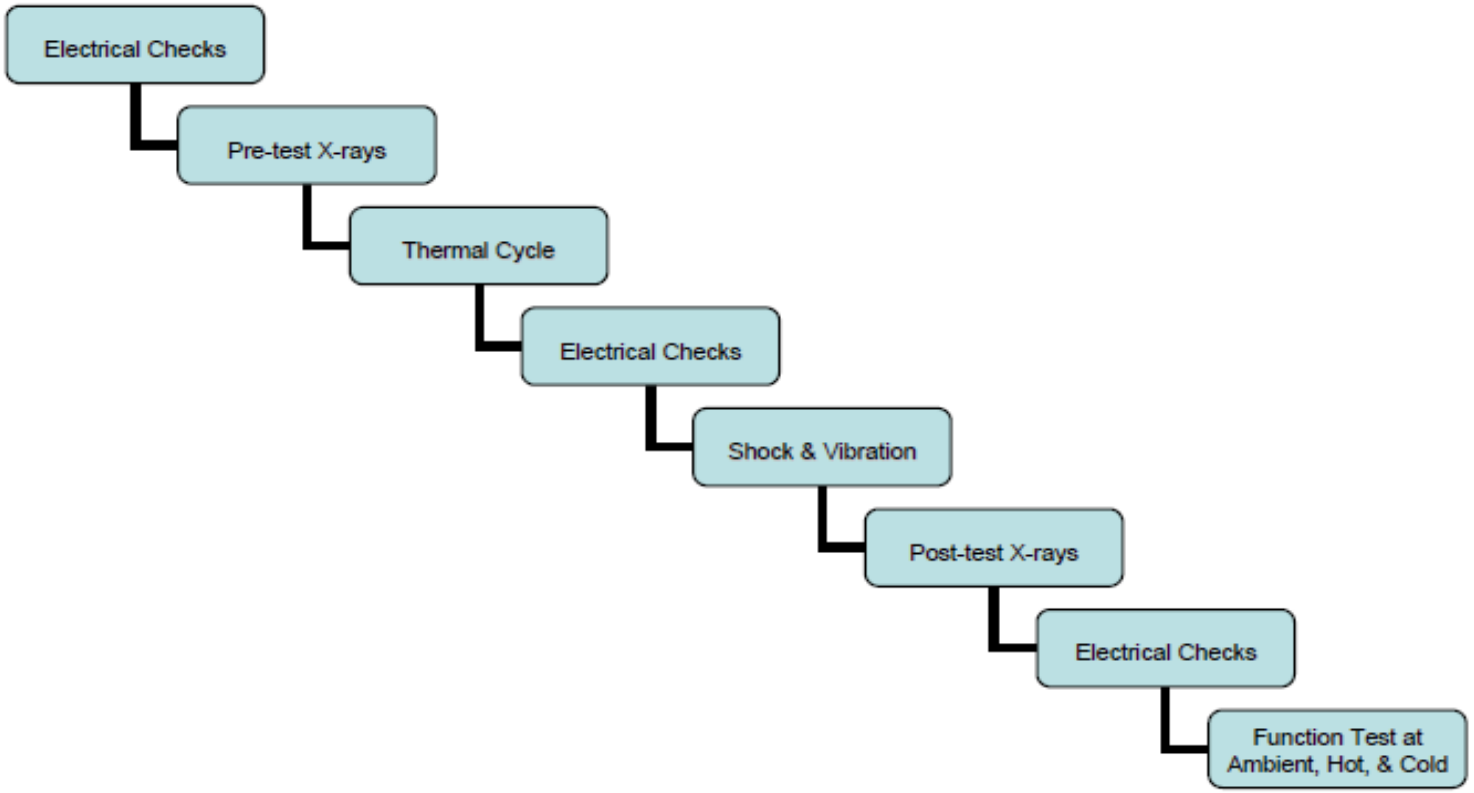


Figure 1. Typical Test Sequence.

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Engineering Design Tests, were performed by the reference of MIL-DTL-23659F.

But we modified some of test routes.

Omit some of them and increase/decrease some test numbers according to our requirements.

TABLE 1: ENGINEERING DESIGN TEST SCHEDULE

TEST	REF. PARA	NUMBER OF INITIATORS (GROUPS)																				TOTAL
		50	6	6	20	20	20	20	20	20	20	20	2	2	2	2	2	2	2	2	2	176	416
Dielectric Withstanding Voltage	4.4.1	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	416
Radiographic Inspection	4.1.2.2	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	416
Leakage	4.1.2.3	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	416
Bridge Circuit Resistance	4.4.2	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	416
Static Discharge	4.4.3.2	X																					50
Bridge Circuit Resistance	4.4.2	X																					50
Stray Voltage	4.4.3.3	X																					50
Bridge Circuit Resistance	4.4.2	X																					50
Power Current or Stimulus 70° F	4.4.3.1 or 4.4.5.1	X																					50
Resistance	4.4.2	X																					50
Forty Foot Drop	4.6.1		X																				6
Six Foot Drop	4.6.2			X																			6
Shock	4.6.3				X								X	X	X	X	X	X	X	X	X		38
Vibration	4.6.4					X							X	X	X	X	X	X	X	X	X		38
Temperature-Shock/Humidity/ Altitude	4.6.5						X																20
Cook-Off	4.6.6.1							X															20
High Temperature Exposure	4.6.6.2								X														20
Salt Fog Test	4.6.7									X													20
Radiographic Inspection	4.1.2.2			X	X	X	X						X	X	X	X	X	X	X	X	X		84
Bridge Circuit Resistance	4.4.2			X	X	X	X		X	X			X	X	X	X	X	X	X	X	X		124
Leakage	4.1.2.3			X	X	X	X						X	X	X	X	X	X	X	X	X		84
Static Discharge	4.4.3.2			X	X	X	X		X	X			X	X	X	X	X	X	X	X	X		124
Bridge Circuit Resistance	4.4.2			X	X	X	X		X	X			X	X	X	X	X	X	X	X	X		124
Power Current or Stimulus 70° F	4.4.3.1 or 4.4.5.1			X	X	X	X			X			X	X	X	X	X	X	X	X	X		104
Power Current or Parmeters 225° F	4.4.3.1 or 4.4.5.1								X		X												40
Bridge Circuit Resistance	4.4.2			X	X	X	X		X	X	X		X	X	X	X	X	X	X	X	X		144
Min. 50 Milli sec. All-Fire 70° F	4.4.4	X		X	X	X				X			X			X			X			X	298
Min. 50 Milli sec. All-Fire -80° F	4.4.6						X					X		X			X			X			46
Min. 50 Milli sec. All-Fire 225° F	4.7								X		X				X			X			X		46

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TABLE 1: ENGINEERING DESIGN TEST SCHEDULE

TESTS	23659F REFERANCE	TEST ROUTES A	B	C	D	E	F	G	H	I	J	K	L	M	N	TOTAL
		50	10	10	20	20	20	20	20	20	20	10	10	10	176	416
Radiografic Inspection	4.1.2.2	50	10	10	20	20	20	20	20	20	20	10	10	10	176	416
Bridge Circuit Resistance	4.4.2	50	10	10	20	20	20	20	20	20	20	10	10	10	176	416
Power Current or Stimulus 70° F	4.4.3.1 4.4.5.1	50														50
Bridge Circuit Resistance	4.4.2	50														50
Forty Foot Drop (12 m)	4.6.1		10													10
Siz Foot Drop (1,5 m)	4.6.2			10												10
Shock	4.6.3				20							10	10	10		50
Vibration	4.6.4					20						10	10	10		50
Temperature/Shock/Humidity/Altitude	4.6.5						20									20
Cook-off	4.6.6.1							20								20
High Temperature Exposure	4.6.6.2								20							20
Radiografic Inspection	4.1.2.2			10	20	20	20					10	10	10		100
Bridge Circuit Resistance	4.4.2			10	20	20	20		20			10	10	10		120
Power Current or Stimulus 70° F	4.4.3.1 4.4.5.1			10	20	20	20					10	10	10		100
Power Current or Stimulus 225° F	4.4.3.1 4.4.5.1								20	20						40
Bridge Circuit Resistance	4.4.2			10	20	20	20		20	20		10	10	10		140
Min 50 ms all fire (70°F)	4.4.4	50		10	20	20						10			176	286
Min 50 ms all fire (-80°F)	4.4.6						20				20		10			50
Min 50 ms all fire (225°F)	4.7								20	20				10		50

																						TOTAL
																						2 2 2 176 416
																						X X X X 416
																						X X X X 416
																						X X X X 416
																						50
																						50
																						50
																						50
																						50
																						6
																						6
																						X X X 38
																						X X X 38
																						20
																						20
																						20
																						20
																						X X X 84
																						X X X 124
																						X X X 84
																						X X X 124
																						X X X 124
																						X X X 104
																						40
																						X X X 144
																						X X X 298
																						X 46
All-Fire -80° F	4.4.6								X					X				X				
Min. 50 Milli sec. All-Fire 225° F	4.7										X		X				X			X		X 46

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Functional tests were done at factory level. During all-fire tests we double checked the explosion time with oscilloscope and fast-cam.

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Activation of explosive train tests: Initiation of Safe and Arm

Dent in block tests

Series of environmental tests were done according to MIL-DTL-23659, STANAG 4157 and AOP-20.

Temperature and humidity cabinets

Vibration and Shock Tests

12m Drop Test

Jolt Test

Jumble Test

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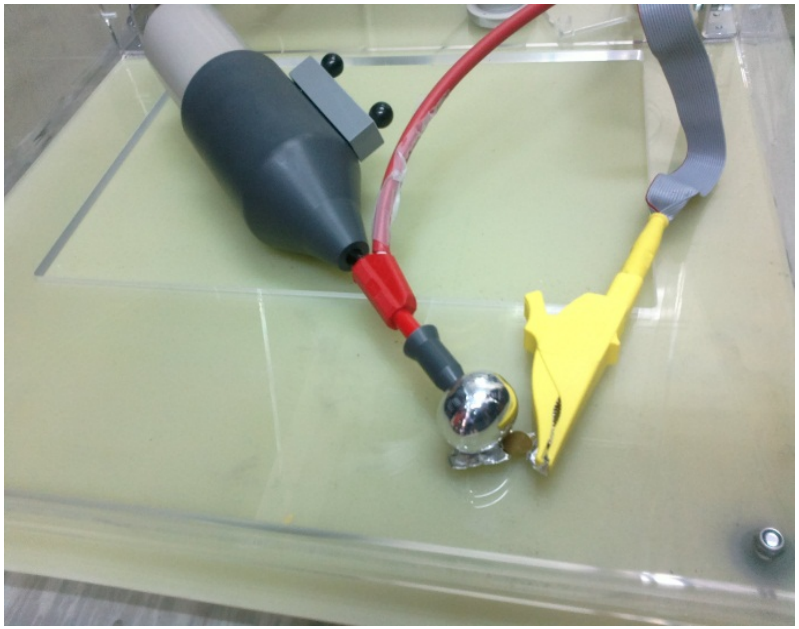
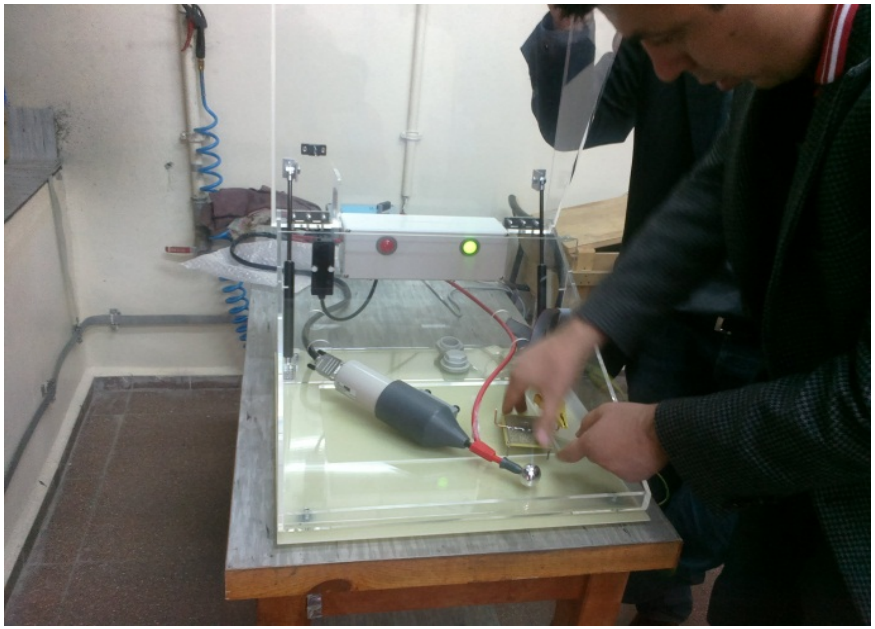
- Electrostatic Discharge(ESD) tests were done.
- >10kV tested.





Characteristics

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	Initiator 1	Initiator 2
All-Fire:	700 mA	350 mA
No-Fire (5 minutes):	450 mA	150 mA
Ignition time (max):	150 microseconds	100 microseconds
Firing Energy:	< 1 mJ	< 1 mJ
Resistance:	2.5-3.5 ohm	4-5 ohm
Dimensions:	~7 mm diameter ~10 mm length double pins	~5 mm diameter ~10 mm length single pin
Operation Temprature:	-54 +71 °C	-54 +71 °C
Service Life:	> 15 years	> 15 years
Explosive Amount:	< 100 miligrams of primary explosive	< 100 mg of primary explosive
Qualification Standard:	MIL-DTL-23659	MIL-DTL-23659

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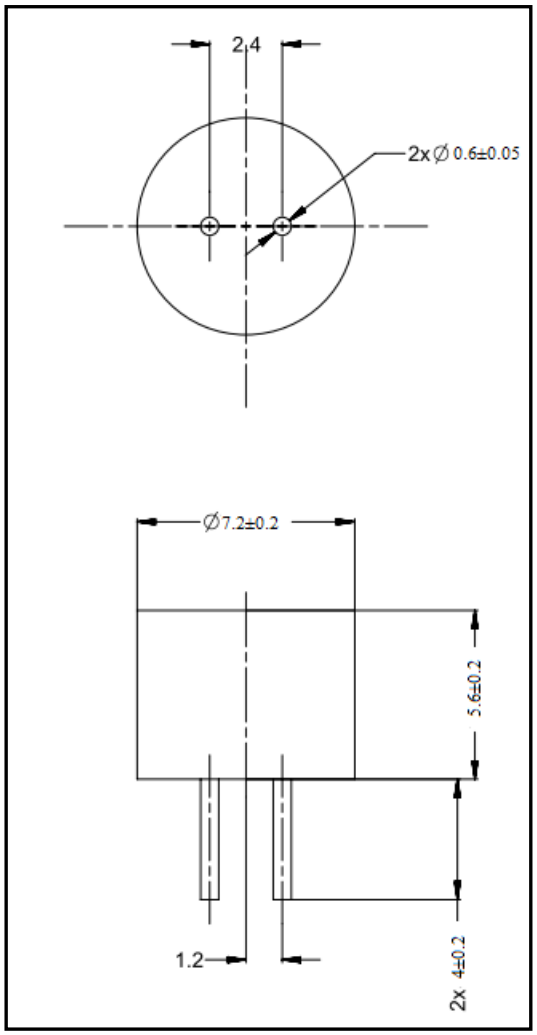

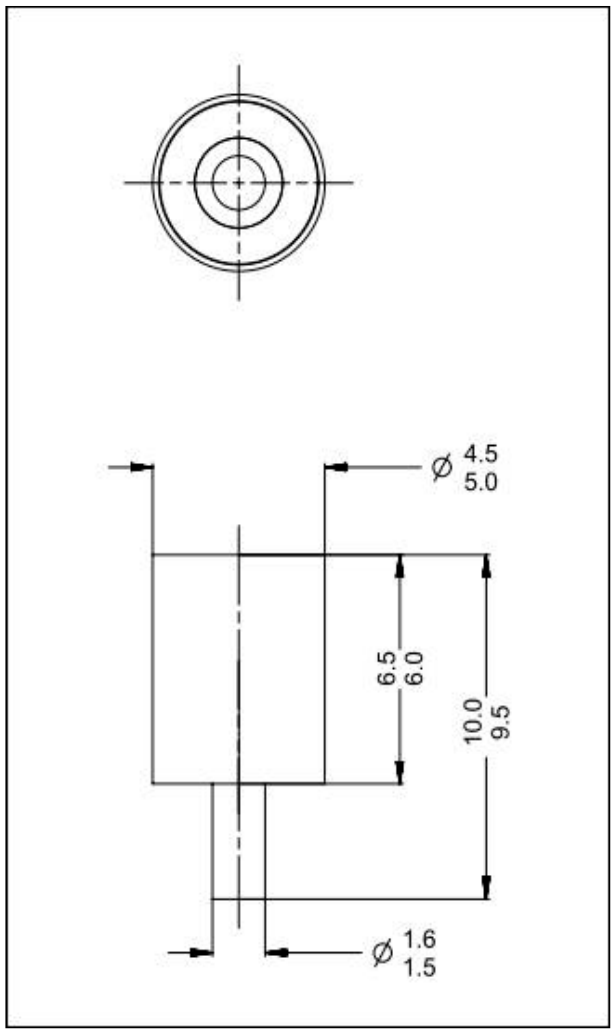

Note: The dimensions provided can be customized.

Conclusion and Future Work

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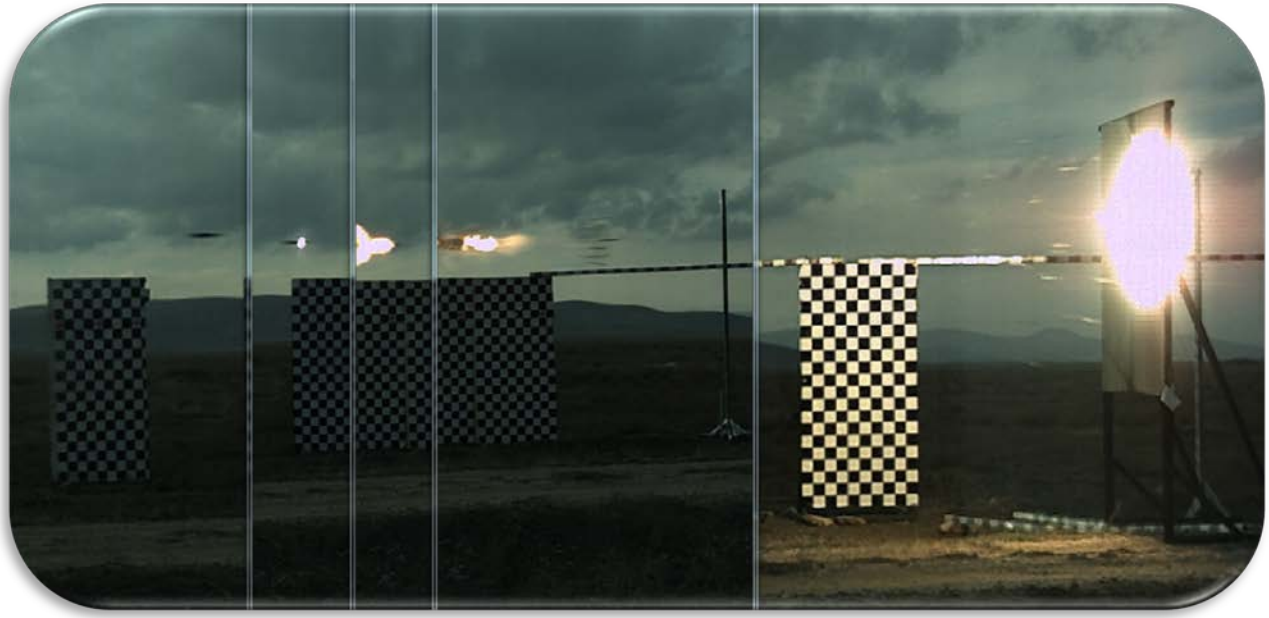
- Low Energy Thin Film Electric Initiators are developed, qualified and field-proven
- Thin Film Electric Initiators have many advantages compared to bridge wire initiators.
- The developed Electric Initiator, which is very fast and requires low energy, meets the design and performance requirements to be used in various kind of fuzes of smart munitions.



Development studies and qualification tests were conducted together with MKEK.

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THANK YOU FOR YOUR ATTENTION!
QUESTIONS?

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