# Advertisement for Incubation of Technology

| Title of the technology | 10 MeV RF LINAC for Food, Medical & Industrial Applications |
|---|---|

**Current state of Technology –**

- ✓ Basic principles observed
- ✓ Technology concept formulated
- ✓ Proof of concept established experimentally
- ✓ Technology validated in lab
- ✓ Technology validated in relevant environment (industrially relevant environment in the case of key enabling technologies)
- ✓ Technology demonstrated in relevant environment (industrially relevant environment in the case of key enabling technologies)
- ✓ System prototype demonstration in operational environment System complete and qualified

**General Information**

Electron beams have played a key role in the field of basic and applied sciences. Over the last few decades, focus has shifted to its industrial applications. Radio Frequency (RF) based 10 MeV EB is found to be highly suitable for food irradiation, medical sterilization, cross linking / scissoring of polymers for cable & tyre industries, semiconductor characteristics modifications, electronic waste management, radiation hardening studies etc. The salient features of the RF EB source are as follows:

- Suitable for wide range of applications
- Uniform controlled dose
- Customized dosing as per treatment plan by varying the pulse repetition frequency
- No radioactive source, and hence no concern of transportation or disposal
- Environment friendly and user friendly

Advantages of EB irradiation are:-

- ✓ Ease of operation
- ✓ High throughput
- ✓ Inherent safety
- ✓ No continuous radiation
- ✓ No security threats

- ✓ Operation in X-Ray mode possible

**Features/Specification of System**

| 10 MeV LINAC Parameters | *For Current* | *For Target System* |
|---|---|---|
| Output Beam Energy | 10 ± 0.5 MeV | 10 ± 0.5 MeV |
| Output Beam Power (Average) | 5 kW | **10-15 kW** |
| Operating Frequency | 2856 ±2 MHz | 2856 ±2 MHz |
| Pulse width | 10 µs | **15-20 µs** |
| Pulse Repetition Frequency (PRF) | 400Hz | 400Hz |
| Injection voltage | 40-50 kV | 40-50 kV |
| Max. output Beam Current (Pulsed) | 125 mA | **250 mA** |

**Working of the System**

A schematic representation of the system is shown in Figure 1. Electrons from the electron gun are injected into the RF LINAC at energy of 40-60 keV. These electrons are then accelerated through the LINAC, up to beam energy of 10 MeV. Microwave power needed for this LINAC is derived from a klystron and fed into the LINAC through the waveguide plumb line. After acceleration, the magnetic sweep scanner deflects the beam in the scan horn and is taken out in the atmosphere through a 100 cm X 8 cm, 50- micron thick titanium foil window for radiation processing applications. The complete LINAC up to titanium foil is maintained in vacuum of $10^{-7}$ Torr with the help of rotary-backed turbo molecular pump and sputter-ion pumps. A fast-current transformer (FCT) at the end of the LINAC is used to measure the output beam current. The LINAC is maintained within permissible temperatures with the help of circulating low-conductivity water. Whole accelerator is cooled by chilled water at 22-25°C. Beam exit window is cooled by forced air circulation through blower. The major operating parameters of the LINAC used as an EB source are given in the following table:

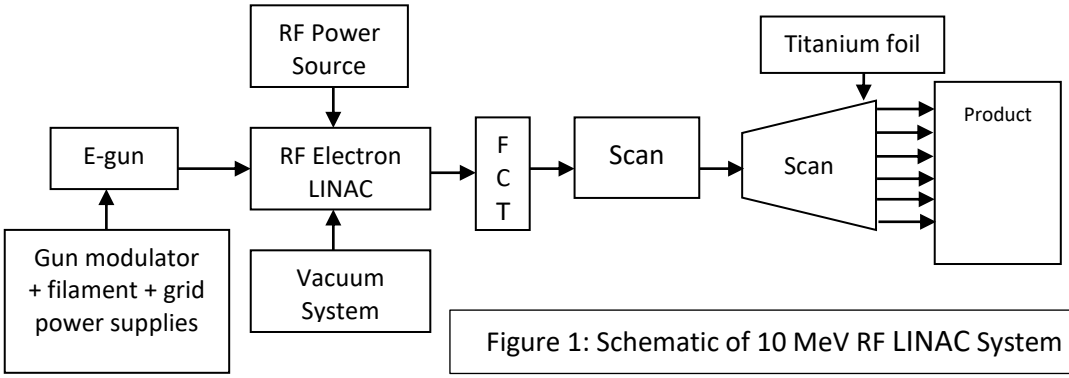


Figure 1: Schematic of 10 MeV RF LINAC System

**Areas of Applications of the Existing System-**

- ✓ Food processing
- ✓ Food disinfestation

- ✓ Semiconductor irradiation
- ✓ Gemstone irradiation
- ✓ Cross linking of polymers
- ✓ X-Ray source for radiography
- ✓ Radiation curing of adhesives
- ✓ Graft polymerization
- ✓ Teflon degradation
- ✓ Medical sterilization

**Applications Demonstrated**

- ✓ Reverse recovery time of a specific diode was observed to reduce from 15 us to 7 us
- ✓ Softening temperature of PE O-rings increased from 70°C to 270 °C
- ✓ Teflon degradation
- ✓ Diamond coloration
- ✓ Photo fission experiments

**Picture/Photo of the System –**

**10 MeV LINAC System**

***Ground Floor Scan Horn View***

***First Floor RF LINAC View***

***E-Gun Modulator (50 kV, 1 A, 400 Hz, 10 μs)***

***E-Gun Filament Supply***

***Electron Gun,*** *70 keV, 1 A, 10 μs, 400 Hz*
*Cathode: LaB6, Configuration: Triode*
*Emission: Thermionic*

***RF LINAC cavity under RF testing***
*Design Values of 10 MeV Cavity Structure*
*Frequency: 2856±2 MHz, VSRW = 2.0*

***Line-type Klystron modulator***
***55 kV, 270 A, 10 μs, 400 Hz***

***Scan magnet and Scan Horn, 200 X 279 x1000 mm (H), Ti Foil – 50 microns***

***Conveyorsystem, Variablespeed: 1 – 7 m/min***

***Control Room***

**Photograph of newly developed 10 MeV, 5kW Horizontal RF LINAC**

System has been tested up to beam power of 3kW. Approval of appropriate regulatory authority in BARC is awaited for beam power testing up to 5kW.

**Whether the parent product/ technology/ process is patented: No**

**Provide the details – NOT APPLICABLE**

**Deliverables –**

10 MeV LINAC will be jointly developed with the incubatee. This development will bring down the cost of the system as well as the cost of irradiation. The major deliverables are:

1. 10MeV RF LINAC system (BARC & Incubatee),
2. Radiation Shielding (Incubatee Party),
3. Integrated testing of 10 MeV (BARC & Incubatee).

**Justification for Incubation –**

The LINAC has been designed and developed for various irradiation applications. It has the following basic components:

i. S-band LINAC of 10 MeV energy,
ii. Klystron based RF Source,
iii. Electron Gun and its power supplies,
iv. Magnetic focusing system,
v. Vacuum, low conductivity water and ozone extraction systems,
vi. Control and instrumentation.

The LINAC technology will cater to the growing need for industrial RF LINACs in irradiation applications.

**Facility and Infrastructure requirements:**

The detailed scope of the work would be discussed with the successful applicant (s) before signing of the Incubation Agreement.

| Title Head | To be provided by BARC | To be provided by Incubatee |
|---|---|---|
| Manpower/ expertise | 7 Nos. | 7 Nos. |
| Infrastructure, Machinery and Equipment | 10MeV Accelerator technology and Radiation shielding design will be provided by BARC. | • Building with proper radiation shielding to house accelerator ensuring safety as per accelerator facility guidelines.<br>• High precision machine shop for fabrication of 10 MeV LINAC and other critical components of LINAC<br>• Chemical and Ultrasonic Cleaning for Oxygen Free High Conductivity (OFHC) Copper cavity<br>• Vacuum brazing furnace capable of producing a hot zone of 1200o C<br>• HV test facility (0-60kVDC/5mA) for testing multiplier components.<br>• LCR meters up to 1MHz range<br>**Measurement Instrument**<br>(i) Vector Network Analyzer with calibration kit<br>(ii) Motorize bead pull setup<br>(iii) High Power Characterization setup (Klystron + |

| | | |
|---|---|---|
| | | RF Line, Remote Control & Instrumentation<br>(iv) High voltage measurement instruments like high bandwidth oscilloscope, Highvoltage probe & current probes etc. |
| Others | Technical discussion and visits to BARC facilities will be arranged for demonstration of existing setup as per requirement. | (i) Certified Radiation Safety officer (RSO) and chemist to test the water parameters and for process development.<br>(ii) Dosimetry lab, safety instruments & chemistry lab<br>(iii) Prior experience and capability of handling Accelerator for irradiation process is desirable. |
| **Economic Viability** | | |
| Investment and unit cost of production | Cost of development of 10MeV, 10-15 kW, RF LINAC Machine is 8-10 Cr (approx.) besides the infrastructure cost of approx. 5.0 Cr. | |
| Imported/indigenous market price of equivalent technology/ process/ product, if available. | The Accelerator Machines available in the market cost 18-19.5 Cr (approx.) | |
| **Special Requirements** | | |
| Any special requirements for plant, industry, location utilities, handling storage, safety etc. | Infrastructure viz. chilled water facility with low conductivity water, Ozone removal system and fresh air blower, conveyor system for product handling system, 2 ton overhead crane, safety instruments, and training of personnel for man and machine safety. | |

**Note: As per in-house technology incubation policy, the incubatee should be a licensee of the existing technology. Alternatively, the applicant will be required to take the license of the existing technology before entering incubation agreement.**

If interested in Incubation, kindly ***download -> fill -> scan -> send*** the application form to -

**Convener**
**Task Force, Incubation Centre - BARC**
**Knowledge Management Group**
**Training School Complex**
**Anushakti Nagar**
**Mumbai - 400094**