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VACUUM ANNEALING FURNACE

Vacuum Annealing Furnace - ToronVF™ Anneal

ToronVF™ Anneal is a high-vacuum annealing furnace for thermal annealing, bake-out, quenching, and heat treatment at 50 to 700 °C. A PID-controlled furnace inside an SS304 vacuum chamber reaches 10^{-7} Torr base pressure with adjustable heating rates of 1 to 20 °C/minute. Quenching and cooling rates up to ±50 °C/minute support rapid thermal processing cycles for time-sensitive heat treatment programs. A programmable 10-step PID profile, expandable to 40 steps, controls each thermal cycle with independent setpoint, ramp, and soak parameters.

The electro-polished SS304 vacuum chamber provides clean surfaces for contamination-sensitive annealing applications, with a wide-range vacuum system spanning 1000 to 10^{-9} Torr. Turbomolecular and mechanical pumps are standard, reaching 10^{-6} Torr in 30 minutes, with a dry pump available as an option. Isolation valves allow chamber backfill with Ar or N_2 as desired, and power failure protection keeps the chamber under vacuum when the system is idle. Rapid cycle times support two to three experiments per day depending on load volume.

The working volume is adjustable across 1 to 3 m^3 to accommodate different batch sizes and loading configurations. Optional mass flow meter gas inputs for Ar, N_2, O_2, He, and other gases enable controlled atmosphere processing alongside vacuum annealing and bake-out applications. A 100 amu residual gas analyzer option identifies outgassing species and monitors chamber cleanliness before and during heat treatment. The 75×120 cm footprint on lockable wheels and touch screen panel with real-time LCD control complete the system.

APPLICATIONS

Vacuum Annealing Furnace - ToronVF™ Anneal Applications

The ToronVF™ Anneal serves research and production facilities requiring clean, oxidation-free heat treatment of metallic, ceramic, and semiconductor materials where atmospheric furnaces would introduce surface oxidation, scale, or undesired

phase reactions. Its bake-out mode, quenching capability, optional controlled atmosphere, and programmable multi-step profiles suit a broad range of thermal processing programs.

- **Vacuum Annealing and Stress Relief**: heat treatment of metals, alloys, and semiconductors at 50 to 700 °C under high vacuum for stress relief, recrystallization, and grain growth without surface oxidation or contamination
- **Magnetic Material Processing**: vacuum annealing of permanent magnets, soft magnetic alloys, and amorphous metals for magnetic property development, coercivity tuning, and hysteresis loss reduction
- **Vacuum Quenching and Rapid Thermal Processing**: rapid cooling at up to ±50 °C/minute for martensite formation, retained austenite management, and metastable phase trapping in alloy systems
- **Bake-Out and Degassing of Vacuum Components**: high-temperature bake-out of vacuum chambers, electrodes, feedthroughs, and components to desorb adsorbed water and hydrocarbons before assembly or use
- **Hydrogen Removal and Dehydrogenation**: vacuum annealing for hydrogen outgassing from titanium, zirconium, steel, and other hydrogen-susceptible materials after electroplating, forming, or joining processes
- **Thin Film and Semiconductor Post-Deposition Annealing**: vacuum annealing of thin film samples to activate dopants, improve crystallinity, and reduce interface defect densities in semiconductor and photovoltaic device research
- **Phase Transformation and Sintering Research**: programmable multi-step vacuum thermal cycles for phase diagram studies, solid-state reaction research, and ceramic or powder metallurgy sintering programs

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FEATURES

Vacuum Annealing Furnace - ToronVF™ Anneal Key Features

The ToronVF™ Anneal integrates a PID-controlled high-vacuum furnace, multi-step programmable thermal profiles, rapid quenching capability, optional residual gas analysis, and automated computer control in a scalable vacuum heat treatment platform with 1 to 3 m^3 adjustable working volume.

- **50 to 700 °C PID Controlled Vacuum Furnace**: precision temperature control inside an SS304 vacuum chamber for clean heat treatment without atmospheric contamination
- **Programmable PID Temperature Profile (10 to 40 Steps)**: multi-step thermal cycle control with independent setpoint, ramp rate, and soak time per step for complex annealing and heat treatment schedules
- **Adjustable Heating Rate (1 to 20 °C/minute)**: operator-selectable ramp rate adapts to material thermal mass, phase transformation requirements, and process sensitivity
- **Quenching and Rapid Cooling at ±50 °C/minute**: high-rate thermal transitions for martensitic hardening, metastable phase formation, and transformation-sensitive heat treatment applications
- **1 to 3 m^3 Adjustable Working Volume**: configurable chamber volume accommodates different batch sizes and loading configurations across research and production programs
- **10^{-7} Torr Base Pressure, 10^{-6} Torr in 30 Minutes**: turbomolecular and mechanical pump combination with fast pump-down for efficient cycle support
- **Turbomolecular and Mechanical Pump (Dry Pump Option)**: standard pump configuration achieves base vacuum for clean annealing; dry pump option available for oil-free system requirements
- **Wide-Range Vacuum Control (1000 to 10^{-9} Torr)**: integrated vacuum measurement and control from atmospheric pressure to deep vacuum for all process modes
- **Optional 100 amu Residual Gas Analyzer**: compositional monitoring of outgassed species during bake-out and annealing for contamination identification and process verification
- **Optional Mass Flow Meter Gas Inputs (Ar, N_2, O_2, He)**: controlled atmosphere capability for gas quench, inert backfill, and atmosphere-assisted processing alongside vacuum annealing modes

- **Isolation Valves with Ar or N_2 Chamber Backfill**: controlled atmosphere after annealing for inert cool-down, gas quench, or specific post-treatment atmosphere requirements
- **Power Failure Protection with Vacuum Hold**: isolation valve maintains chamber vacuum in the event of power loss, protecting sensitive samples and preserving the process environment
- **Rapid Cycle Times (2 to 3 Experiments Per Day)**: fast pump-down and cycle design allows multiple heat treatment runs per day depending on load volume
- **SS304 Electro-Polished Vacuum Chamber**: clean, low-outgassing chamber surfaces reduce contamination risk for high-purity annealing processes
- **Closed-Loop Water Cooling (When Needed)**: thermal management of furnace and chamber components during sustained high-temperature operation
- **Fully Automatic Computer Control with Touch Screen and LCD Panel**: all temperature, pressure, and process parameters managed automatically with real-time monitoring throughout each heat treatment cycle
- **75×120 cm Mobile Platform on Lockable Wheels**: compact footprint for flexible laboratory and production floor placement
- **Two-Year Warranty for Design, Materials, and Workmanship**: extended coverage consistent with the system's positioning as a long-term research and production investment

THEORY & METHOD

Theory and Method

Vacuum annealing heats materials under low-pressure conditions, using the absence of oxygen and reactive gases to prevent surface oxidation and interstitial contamination during heat treatment. At pressures below 10^{-5} Torr, residual gas concentrations are insufficient to contaminate the material surface, preserving surface chemistry and enabling grain boundary diffusion for microstructural development. Applications include stress relief, recrystallization, hydrogen outgassing, phase transformation, and magnetic property development. Controlled Ar or N_2 backfill after annealing adjusts the cooling

rate for controlled transformation or quench.

The programmable PID profile, expandable to 40 steps, controls each annealing cycle with independent setpoint, heating rate, and soak per step. Multi-step flexibility accommodates complex schedules including multi-stage annealing with intermediate hold temperatures, stress-relief ramps, and controlled cooling sequences. Quenching at up to ±50 °C/minute allows rapid thermal transitions for martensite formation, metastable phase trapping, and transformation-sensitive processes. Adjustable heating rates of 1 to 20 °C/minute complement the quench capability for precise thermal cycle control.

Bake-out at up to 700 °C desorbs water, solvents, and hydrocarbons from chamber surfaces and components, lowering effective base pressure. The turbomolecular pump removes desorbed species continuously during the thermal cycle, improving chamber cleanliness with each bake-out run. An optional 100 amu residual gas analyzer monitors outgassed species and confirms chamber cleanliness before sensitive downstream processes. Wide-range vacuum measurement spanning 1000 to 10^{-9} Torr and isolation valve protection complete the vacuum system.

TECHNICAL SPECIFICATIONS

Vacuum Annealing Furnace - ToronVF™ Anneal Technical Specifications

Parameter	Specification
Furnace Temperature Range	50 to 700 °C
Temperature Control	PID
Heating Rate	1 to 20 °C/minute (adjustable)
Quenching / Cooling Rate	Up to ±50 °C/minute
Temperature Profile	10-step programmable PID (expandable to 40 steps)
Base Pressure	10^{-7} Torr

Parameter	Specification
Working Vacuum (Pump-Down Time)	10^{-6} Torr in 30 minutes
Vacuum Control Range	1000 to 10^{-9} Torr
Chamber Material	Stainless Steel Type 304; electro-polished
Working Volume	1 to 3 m^3 (adjustable)
Pump Configuration	Turbomolecular + Mechanical (dry pump as option)
Gas Inputs (Optional)	MFM controlled; Ar, N_2, O_2, He, and others
Chamber Backfill	Ar or N_2 (via isolation valves)
Residual Gas Analyzer (Optional)	100 amu
Cooling System	Closed-loop water cooling (when needed)
Power Failure Protection	Yes; isolation valve maintains vacuum
Control System	Fully automatic computer control; touch screen; real-time LCD
Experiment Throughput	2 to 3 per day (depending on load volume)
Footprint	75 × 120 cm
Mobility	Lockable wheels
Warranty	2 years (design, materials, and workmanship)

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