SA-AFM

Use the SA-AFM for scanning life science samples, large samples, routine scanning of technical samples, or for nanotechnology research.

The SA-AFM is a complete system and includes everything required for scanning all sizes and shapes of samples.

It is easily integrated with all manufacturers' inverted microscopes.

► Flexible, stand alone design
► Scans any sample size
► Adaptable to inverted microscopes
► Linearized XY piezoelectric scanner
► Accommodates widest range of standard AFM probes
► All standard modes, including vibrating, non-vibrating, and phase
► Direct drive motorized probe approach
► Intuitive LabVIEW™-based software for image capture

Using the industry-standard light lever force sensor, all standard scanning modes are included with the system. Vibrating mode is used for high resolution and soft samples, while non-vibrating mode can be used for routine scanning. Also included with the system are phase and lateral force modes.

Control software, written in LabVIEW™, is simple and intuitive to use. Differing windows walk users through the process: a pre-scan window helps align the AFM probe, a scanning window aids in acquiring images, a force position window measures force distance curves, and finally, a system window assists in altering system parameters.

SA-AFM MEASUREMENTS

In addition to measuring surface structure, the SA-AFM is ideal for modes measurements. For example these images are of a polymer sample.

The top image is the topography image and the bottom image is the phase image, measuring the relative hardness of the polymer sample.
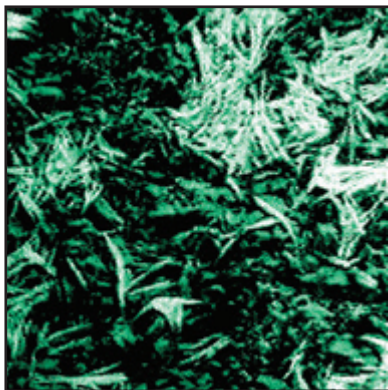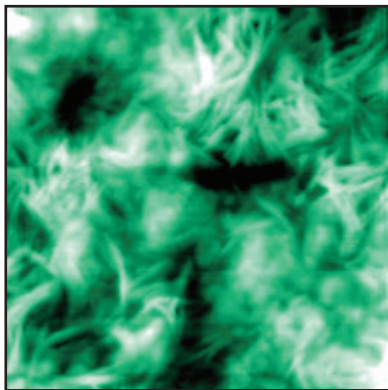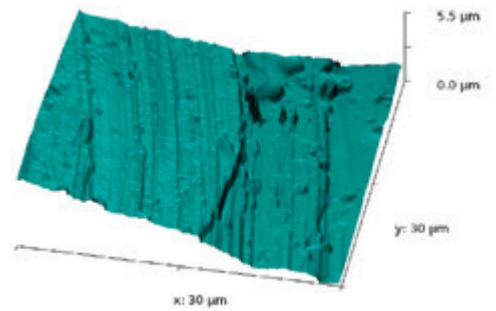

► ## Surface Texture

Surface texture on polished and machined surfaces is readily measured with the SA-AFM.

With the SA's flexible stage design, fixtures for holding almost any sample shape can be created.

Once measured, the AFM images can be analyzed and standard surface texture parameters such as Ra are readily calculated.

Polished Surface - 30 x 30 x 5 µm

► ## Dimensional

Atomic force microscopes are capable of accurately measuring the dimensions of semiconductor and other micro-fabricated devices. Because the SA-AFM accommodates commercially available AFM probes, specialized probes for metrology measurements can be used.
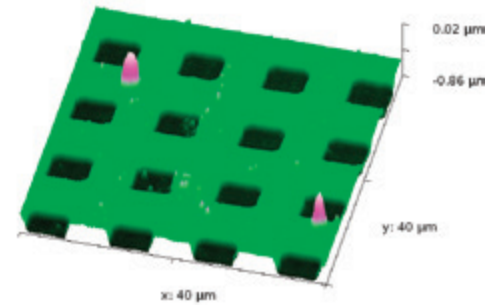

Calibration reference - 40 x 40 x 1 µm

► ## Visualization

One of the most powerful capabilities of the SA-AFM is the capability to visualize surface structure. Although not easily quantified, the surface texture of this cell structure is readily visualized.

Features that may be readily visualized with the SA-AFM range in size from a few nm to a few µm.

Cells - 8x8 µm

AFM WORKSHOP™
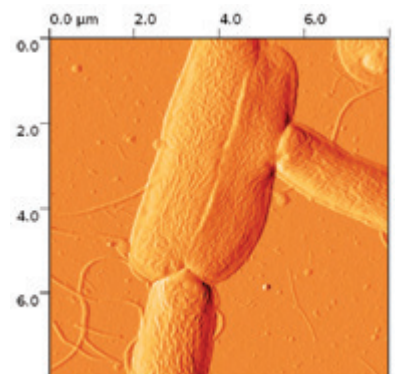
SA-AFM STAGE

► **High Resolution Z Stage**

The direct drive's Z stage controls motion down to 330 nm, assuring optimal tip approach. Software controls for the Z stage rapidly move the light lever up and down and regulate the automated probe approach.

► **Light Lever Force Sensor**

An industry-standard light lever force sensor is utilized in the SA-AFM. The probe holder accommodates the widest range of commercially available AFM probes. The light lever force sensor can make measurements in standard modes, including vibrating, nonvibrating, lateral force, and phase mode.

► **Video Microscope**

The high resolution video microscope has a zoom tube which allows a field of view between 2 x 2 mm and .3 x .3 mm. The video microscope is essential for aligning the light lever laser, locating features for scanning, and facilitating tip approach.

► **XY Piezo Scanner**

For XY scanning, linearized piezo electric ceramics utilize real time feedback control to assure accurate measurements. The multiple modified tripod design (MMTD) of the XY scanner provides scans with minimal background bow.

► **Probe holder**

A modular probe holder is used in the light lever force sensor and held in place with a spring clip. Probes can be replaced in less than two minutes with the probe exchange tool. Additionally, the probe holder's spring clip can be used to supply voltages to the AFM probe for techniques such as conductive AFM.

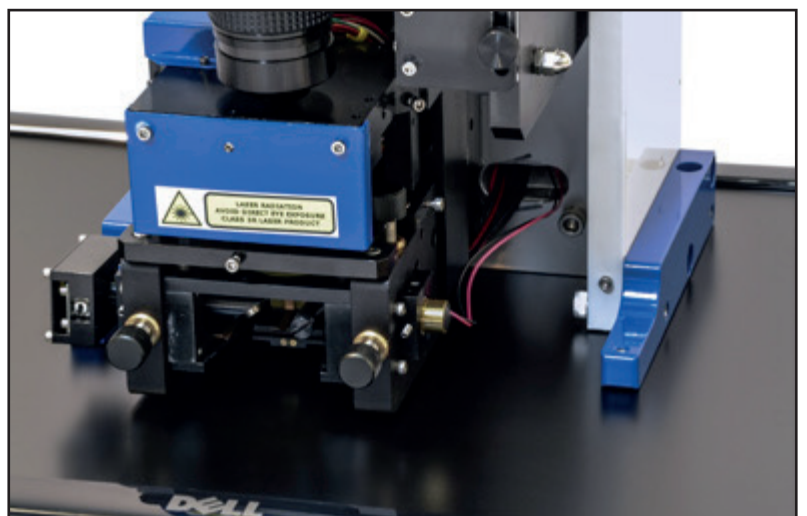High resolution 3MP CCD color camera video microscope

High performance linear Z translator

XYZ video microscope positioning

Linearized XY scanner

Light lever force sensor

Small footprint high stability stage structure

Large objects that will not fit in a traditional stage may be imaged with the SA-AFM. In this example, the monitor of a commercial AFM is being imaged.

AFM WORKSHOP™

EBOX

Electronics in the SA-AFM are constructed around industry-standard USB data acquisition electronics. The critical functions, such as XY scanning, are optimized with a 24-bit digital to analog converter. With the analog Z feedback loop, the highest fidelity scanning is possible. Vibrating mode scanning is possible with both phase and amplitude feedback using the high sensitivity phase detection electronics.

► **24-bit scan DAC**

Scanning waveforms for generating precision motion in the XY axis with the piezo scanners are created with 24-bit DACS driven by a 32-bit micro controller. With 24-bit scanning, the highest resolution AFM images may be measured. Feedback control using the XY strain gauges assures accurate tracking of the probe over the surface.

► **Phase and Amplitude Detector Circuit**

Phase and amplitude in the Ebox are measured with highly stable phase and amplitude chips. The system can be configured to feed back on either phase or amplitude when scanning in vibrating mode.

► **Signal Accessible**

At the rear of the Ebox is a 50 pin ribbon cable that gives access to all of the primary electronic signals without having to open the Ebox.

► **Precision Analog Feedback**

Feedback from the light lever force sensor to the Z piezoceramic is made using a precision analog feedback circuit. The position of the probe may be fixed in the vertical direction with a sample-and-hold circuit.

► **Variable Gain High Voltage Piezo Drivers**

An improved signal to noise ratio, as well as extremely small scan ranges are possible with the variable gain high voltage piezo drivers.

Microprocessor for scan generation through 24-bit DAC's

Low noise, variable gain high voltage amplifiers with PID feedback for XY scanning

Dimensions: Width 6" | Height 10" | Depth 14"

High fidelity, low noise Z feedback circuits for accurate probe tracking

Phase and amplitude detection circuits for vibrating mode AFM

Industry-standard National Instruments USB data acquisition board

Internally accessible header for signal input/output

Eight channels of ADC for monitoring and displaying data with LabVIEW™ software

SOFTWARE

Software for acquiring images is designed with the industry-standard LabVIEW™ programming visual interface instrument design environment.

Functions such as setting scanning parameters, probe approach, frequency tuning and real time image display are all standard, and included with the product.
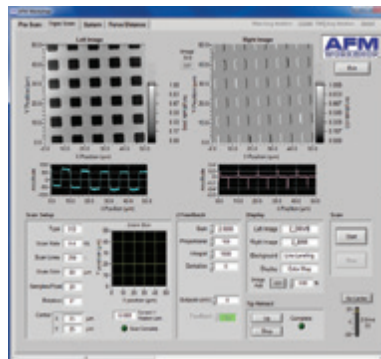
If special enhancements are needed, LabVIEW™'s programming environment facilitates rapid software development. LabVIEW™ standards ensure that the SA-AFM can be combined with any other instrument using LabVIEW™ VI.
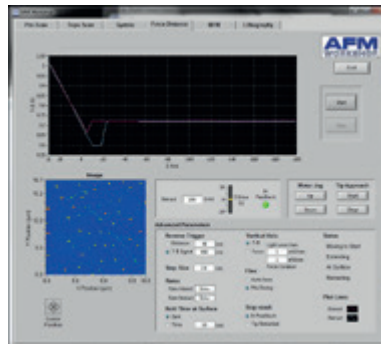
▶ Pre-scan Window

A pre-scan window presents users with a logical sequence of all functions required before initiating a scan.
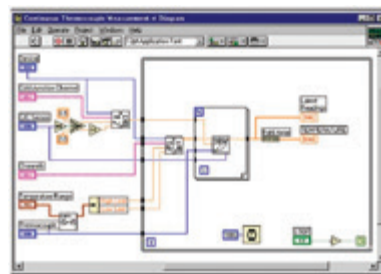
▶ Scan Window

Once the steps in the pre-scan window are completed, the scan window is used for measuring images. Scan parameter, Z feedback parameters, and image view functions may be changed with dialogs on this screen.

Force/Distance Curves

▶

Optional Advanced Force/Distance software may be purchased. This option requires a TS-17Z Z scanner.

▶ LabVIEW™ Window

LabVIEW™ is an industry-standard programming environment for controlling instrumentation. All the software for the SA-AFM is written with LabVIEW™ and can be readily customized for specialized applications.

Any instrumentation already using LabVIEW™ can be added to the SA-AFM to create new capabilities.

IMAGE ANALYSIS SOFTWARE

Included with the SA-AFM is Gwyddion open source SPM image analysis software. This complete image analysis package has all the software functions necessary to process, analyze and display SPM images.

» Visualization: false color representation with different types of mapping

» Shaded, logarithmic, gradient- and edge-detected, local contrast representation, Canny lines

» OpenGL 3D data display: false color or material representation

» Easily editable color maps and OpenGL materials

» Basic operations: rotation, flipping, inversion, data arithmetic, crop, resampling

» Leveling: plane leveling, profiles leveling, three-point leveling, facet leveling, polynomial background removal, leveling along userdefined lines

» Value reading, distance and angle measurement

» Profiles: profile extraction, measuring distances in profile graph, profile export

» Filtering: mean, median, conservative denoise, Kuwahara, minimum, maximum, checker pattern removal

» General convolution filter with user-defined kernel

» Statistical functions: Ra, RMS, projected and surface area, inclination, histograms, 1D and 2D correlation functions, PSDF, 1D and 2D angular distributions, Minkowski functionals, facet orientation analysis

» Statistical quantities calculated from area under arbitrary mask

» Row/column statistical quantities plots

» ISO roughness parameter evaluation

» Grains: threshold marking and un-marking, watershed marking

» Grain statistics: overall and distributions of size, height, area, volume, boundary length, bounding dimensions

» Integral transforms: 2D FFT, 2D continuous wavelet transform (CWT), 2D discrete wavelet transform (DWT), wavelet anisotropy detection

» Fractal dimension analysis

» Data correction: spot remove, outlier marking, scar marking, several line correction methods (median, modus)

» Removal of data under arbitrary mask using Laplace or fractal interpolation

» Automatic XY plane rotation correction

» Arbitrary polynomial deformation on XY plane

» 1D and 2D FFT filtering

» Fast scan axis drift correction

» Mask editing: adding, removing or intersecting with rectangles and ellipses, inversion, extraction, expansion, shrinking

» Simple graph function fitting, critical dimension determination

» Force-distance curve fitting

» Axes scale calibration

» Merging and immersion of images

» Tip modeling, blind estimation, dilation and erosion

Quantum Design

AFM WORKSHOP™

VIDEO MICROSCOPE

A video optical microscope in an AFM serves three functions: aligning the laser onto the cantilever in the light lever of the AFM, locating surface features for scanning, and facilitating probe approach. The SA-AFM includes a high performance video optical microscope along with a 3 megapixel camera, light source, microscope stand, and Windows software for displaying images.
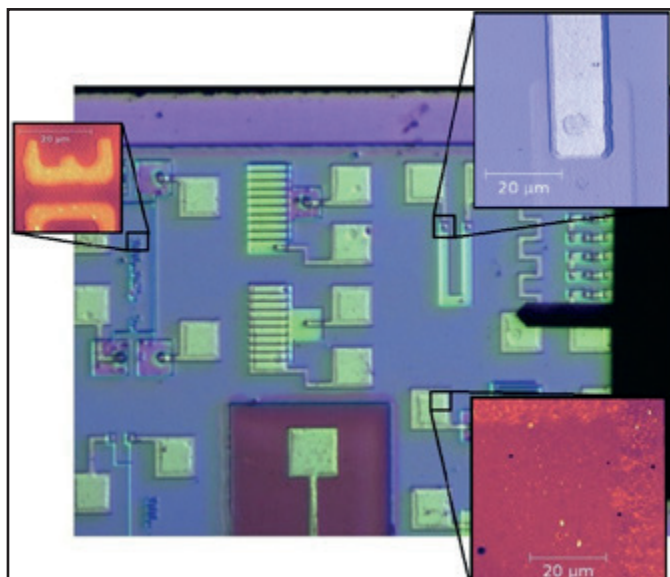
Here the video optical microscope allows viewing features on a test structure. The AFM cantilever is on the right. Three images show results of areas selected for AFM scanning.
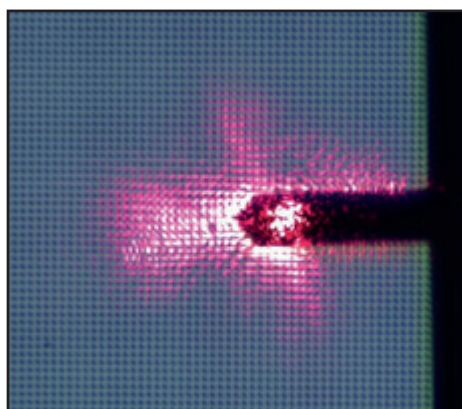
Laser alignment is greatly facilitated with the video optical microscope. This vibrating cantilever is 250 µm long. The red spot is from the laser reflecting off the cantilever.
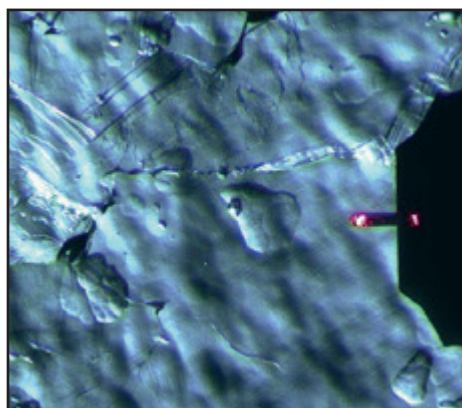

The video optical microscope zooms in to show an HOPG sample surface and the AFM cantilever.

Quantum Design

AFM WORKSHOP™

PROBE HOLDER/ EXCHANGE

The SA-AFM utilizes a unique probe holder/exchange mechanism. Probes are held in place with a spring device that mates with a probe exchange tool.

This combination makes changing probes fast and easy on the SA-AFM.

Probe holder

Probe inserted in clip

Probe exchange tool
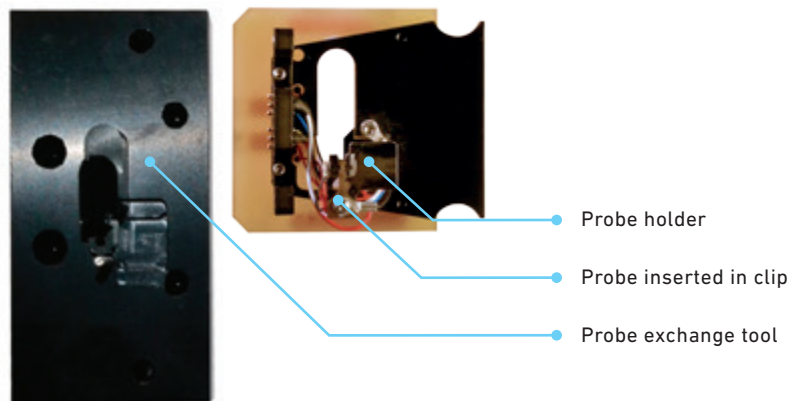
SCANNING MODES

Standard with every SA-AFM are nonvibrating (NV) mode and vibrating (V) modes for creating topography scans.

Additional modes included with the product are lateral force imaging and phase mode imaging.

Any scanning mode that can be implemented with a light lever AFM is possible with the SA-AFM.
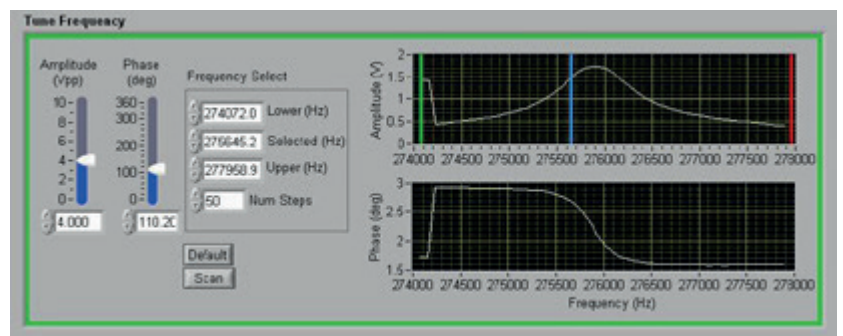
With the window above the resonance frequency of a cantilever is readily measured. Additionally, the phase characteristics of the probe-sample interaction may be captured.

SPECIFICATIONS

▶ 40 Micron XYZ Scanner
- » Type — Modified Tripod
- » xy Linearity — < 1%
- » xy Range — > 40 μm
- » xy Resolution — < 3 nm closed loop
  < 0.3 nm open loop
- » xy Actuator type — Piezo
- » xy Sensor type — Strain Gauge

▶ 16 Micron Z Scanner / Probe Holder
- » Noise — < 0.2 nm
- » Strain Gauge Resolution — 1 nm
- » Tip Angle — 10°
- » Z Linearity — < 5%
- » Z Linearity-Sensor — < 1%

▶ 7 Micron Z Scanner / Probe Holder
- » Noise — < 0.12 nm
- » Strain Gauge Resolution — na
- » Tip Angle — 10°
- » Z Linearity — < 5%

▶ Light Lever AFM Force Sensor
- » Probe Types — Industry-standard
- » Probe Insertion — Manual
- » Probe Exchange — Tool
- » Probe Holding Mechanism — Clip
  Vibrating Mode Piezo
  Electrical Connector
  to Probe
- » Laser/Detector Adjustment Range — +/- 1.5 mm
- » Adjustment Resolution — 1 μm
- » Minimum Probe to Objective — 25 mm
- » Laser Type — 670 nm Diode, < 3 mW
- » Laser Focus — < 25 μm
- » Detector
  - Type — 4 Quadrant
  - Band Width — > 500 kHz
  - Signals Transmitted — TL, BL, TR, BR
  - Gain — Low, High Settings
- » Probe sample angle — 10°

▶ Digital Data Input Output
- » Connection — USB
- » Scanning DAC
  - Number — 2
  - Bits — 24
  - Frequency — 7 kHz
- » Control DAC
  - Number — 2
  - Bits — 14
  - Frequency — 2 kHz
- » ADC
  - Number — 8
  - Bits — 14
  - Frequency — 48 kHz

▶ Z Motion
- » Type — Direct Drive
- » Range — 25 mm
- » Drive Type — Stepper Motor
- » Min. Step Size — 330 nm
- » Slew Rate — 8 mm/minute
- » Limit Switch — Top, Bottom
- » Control — Software – Rate,
  Step Size

▶ Analog Electronics
- » Vibrating Mode
  - Freq Range — 2 kHz – 800 kHz
  - Output Voltage — 10 Vpp
  - Demod. Freq — TBD
- » Z Feedback
  - Type — PID
  - Bandwidth — > 3 kHz
  - Sample Hold — Yes
  - Voltage — 0 – 150 V
- » xy Scan
  - Voltage — 0 – 150 V
  - Bandwidth — > 200 Hz
  - Pan & Zoom — 22 Bits
- » Tip Approach Cutoff — < 20 μm sec.

▶ Software
- » Environment — LabVIEW™
- » Operating System — Windows
- » Image Acquisition — Real Time Display
  (2 of 8 channels)
- » Control Parameters
  - PID — Yes
  - Setpoint — Yes
  - Range — Yes
  - Scan Rate — Yes
  - Image Rotate — 0 and 90°
- » Laser Align — Yes
- » Vibrating Freq. Display — Yes
- » Force Distance — Yes
- » Tip Approach — Yes
- » Oscilloscope — Yes
- » Image Store Format — Industry-standard
- » Image Pixels — 16 x 16 to 1024 x 1024
- » H.V. Gain Control — XY and Z
- » Real Time Display — Line Level,
  Light Shaded,
  Grey Color Palette
- » Calibration — System Window
- » Probe Center — Yes

AFM WORKSHOP™

SPECIFICATIONS *CONTINUED...*

▶ Video Microscope

	Minimum Zoom	Maximum Zoom
Field of view	2 X 2 mm	300 X 300 u
Resolution	20 µm	2 µm
Working Distance	114 mm	114 mm
Magnification	45 X	400X

▶ Computer

» Industry-standard Computer & Monitor
(laptop available upon request)
» Windows
» AFMWorkshop LabVIEW.exe installed

▶ Stage
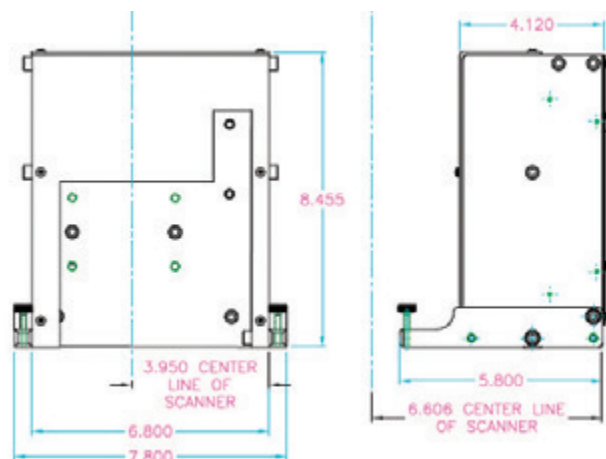
Back and side view of the SA-AFM stage without the AFM/ video microscope. The feet at the bottom may be removed if the stage is rigidly mounted to a surface.

* *Z Noise performance depends greatly on the environment the SA-AFM is used in. Best Z noise performance is obtained in a vibration free environment.*

** *Every effort is made to present accurate specifications, however, due to circumstances beyond AFMWorkshop's control, specifications are subject to change.*