

What is claimed is:

1. A non-contact microwave testing system for see-through imaging of an area under testing, comprising:
  - a front-end subsystem for transmitting and receiving electromagnetic waves to and from the area under testing;
  - a system in package (SiP) subsystem comprising transmitter and receiver radio frequency (RF) chains; and
  - a signal processing subsystem to perform reconstruction of spatial reflectivity of heterogeneous multi-layered media in the area under testing.
2. The system of claim 1, wherein the front-end subsystem comprises at least one transmitter antenna and at least one receiver antenna.
3. The system of claim 1, wherein the front-end subsystem comprises at least one transceiver.
4. The system of claim 2 or 3, wherein each antenna or transceiver is integrated with a metamaterial-based lens that enables sub-wavelength, high-resolution imaging.
5. The system of claim 1, wherein the system in package (SiP) subsystem generates a stepped frequency continuous waveform (SFCW).
6. The system of claim 5, wherein the signal processing subsystem comprises backpropagation algorithms for reconstruction of spatial reflectivity suitable for multi-layered media and SFCW waveform.
7. The system of claim 1, further comprising:
  - a localization subsystem; and
  - an interface subsystem for reconstruction of a high-resolution image.

8. The system of claim 7, wherein the localization subsystem comprises optical flow sensors, an inertial measurement unit (IMU), and barometric pressure sensors.
9. The system of claim 7, wherein the interface subsystem transfers data from the signal processing subsystem to a cloud server or local tablet PC for reconstruction of the high-resolution image.
10. The system of claim 7, wherein the front-end subsystem is a beam focusing MIMO front-end subsystem comprising an array of transmitter antennas that are time-division multiplexed and an array of receiver antennas forming a virtual antenna array based on the physical arrangement of the transmitter and receiver antennas;  
wherein the system in Package (SiP) subsystem is a MIMO SiP subsystem comprising the transmitter and receiver RF chains for generating a stepped frequency continuous waveform ; and,  
wherein the localization subsystem provides location information of the system for the signal processing subsystem to synthesize a large synthetic aperture for 3D image reconstruction.
11. The system of claim 7,  
wherein the front-end subsystem is a beam focusing antenna front-end subsystem comprising a single transceiver;  
wherein the system in Package (SiP) subsystem is a monostatic reflectometer array SiP subsystem comprising the transmitter and receiver RF chains for generating stepped frequency continuous waveform;  
wherein the signal processing subsystem is a digital beamforming signal processing subsystem;  
wherein the localization subsystem is deployed on a moving platform and provides the location information of the system for the signal processing subsystem to synthesize a large synthetic aperture for 3D image reconstruction.

12. The system of any of claims 1 to 11, wherein each antenna element or transceiver operates in the frequency range from 0.1 GHz to 10 GHz, preferably from 0.1 GHz to 6 GHz.
13. The system of claim 4, wherein the metamaterial-based lens is made from double negative materials (DNG) having the property of negative index, which enables sub-wavelength high-resolution imaging.
14. The system of claim 13, wherein the metamaterial-based lens contains concentric periodic split-ring resonators (SRRs) of varying sizes and concentric circular trace lines running in the bottom layer of the lens.
15. The system of claim 4, wherein the lens is placed on top of the antenna element or transceiver for long-distance non-penetrative scanning.
16. The system of claim 1, wherein the system is configured to be hand-held, mounted/fixed on a payload-carrying, autonomous/semi-autonomous/controlled system selected from an unmanned ground vehicle (UGV), a drone, a robotic arm, a crawler robot and/or a combination thereof for non-destructive inspection of facilities such as facade structures, cladding systems, concrete pillars and walls, indoor mechanical, electrical and plumbing (MEP) fittings, water, oil and gas pipelines, metallic parts, roads, tree trunks, tunnels, dams, bridges, medical imaging, security surveillance and warehouse sorting.
17. The system as claimed in claim 16, wherein the system is configured to be hand-held, and wherein the front-end subsystem comprises:
  - a single input single output (SISO) configuration consisting of a single transmitting and receiving wideband antenna elements;
  - a monostatic array of antenna elements; or
  - a MIMO array of antenna elements.
18. The system as claimed in claim 16, wherein the system is mounted/fixed on a payload-carrying, autonomous/semi-autonomous/controlled system selected

from a unmanned ground vehicle (UGV) , drone , robotic arm and crawler robot,  
and wherein the front-end subsystem comprises:

a beam focusing antenna sub system with a single transceiver;

a MIMO sub system with multiple transceivers; or

a monostatic array of reflectometers.

19. A method for non-contact see-through imaging of an area under testing using the system according to claim 1, the method comprising the steps of:  
generating electromagnetic waves by the SiP subsystem;  
transmitting the generated electromagnetic waves to the front-end system through an RF interface;  
transmitting and receiving backscattered signals to the front-end subsystem from the area under testing;  
routing received RF signals to the signal processing subsystem by the SiP subsystem for signal processing and reconstruction of spatial reflectivity of heterogeneous multi-layered media in the area under testing.

20. The method of claim 19, further comprising the steps of:  
combining data from the SiP subsystem and a localization subsystem by the signal processing subsystem to perform 3D image reconstruction algorithms and data interpretation schemes which are routed to an interface subsystem;  
routing the data interpretation and the reconstructed 3D image by the interface subsystem through wired or wireless transmission to a cloud server or local tablet PC for a user to visualise the image of the area under testing.

21. The method of claim 19, wherein a stepped frequency continuous wave (SFCW waveform) is generated by the SiP subsystem.

22. The method according to claim 19, wherein the backscattered signals from the area under testing are directly sampled at an aperture of the front-end subsystem, by a reflectometer utilizing a Schottky diode at an aperture of an antenna with a metamaterial-based lens.

23. The method according to claim 20, wherein a dead reckoning algorithm for IMU is combined with an optical flow sensor, for retrieving accurate coordinate information from the localization subsystem.